UNIVERSITY OF CALIFORNIA PUBLICATIONS.

COLLEGE OF AGRICULTURE.

AGRICULTURAL EXPERIMENT STATION.

CULTURE WORK AT THE SUBSTATIONS

1899-1901.

By CHARLES H. SHINN, Inspector of Stations.

BULLETIN No. 147.

(Berkeley, June, 1902)

SACRAMENTO:

W. W. SHANNON, : : : : : SUPERINTENDENT STATE PRINTING.

1903.

BENJAMIN IDE WHEELER, Ph.D., LL.D., *President of the University.*

EXPERIMENT STATION STAFF.

E. W. HILGARD, Ph.D., LL.D., *Director and Chemist.*
E. J. WICKSON, M.A., *Horticulturist, and Superintendent of Central Station Grounds.*
W. A. SETCHELL, Ph.D., *Botanist.*
ELWOOD MEAD, M.S., C.E., *Irrigation Engineer.*
R. H. LOUGHRIDGE, Ph.D., *Agricultural Geologist and Soil Physicist.* (*Soils and Alkali.*)
C. W. WOODWORTH, M.S., *Entomologist.*
M. E. JAFFA, M.S., *Assistant Chemist.* (*Foods, Fertilizers.*)
G. W. SHAW, M.A., Ph.D., *Assistant Chemist.* (*Soils, Beet-Sugar.*)
RALPH E. SMITH, B.S., *Plant Pathologist.*
GEORGE E. COLBY, M.S., *Assistant Chemist.* (*Fruits, Waters, Insecticides.*)
LEROY ANDERSON, M.S.A., *Animal Industries*, San Luis Obispo.
A. R. WARD, B.S.A., D.V.M., *Veterinarian, Bacteriologist.*
E. H. TWIGHT, B.Sc., Diplomé E.A.M., *Viticulturist.*
E. W. MAJOR, B.Agr., *Dairy Husbandry.*
A. V. STUBENRAUCH, M.S., *Assistant Horticulturist and Superintendent of Substations.*
WARREN T. CLARKE, *Assistant Field Entomologist.*
H. M. HALL, M.S., *Assistant Botanist.*
C. H. SHINN, B.A., *Inspector of Stations.* (Resigned.)
C. A. TRIEBEL, Ph.G., *Student Assistant in Agricultural Laboratory.*
C. A. COLMORE, B.S., *Clerk to the Director.*

EMIL KELLNER, *Foreman of Central Station Grounds.*
JOHN TUOHY, *Patron*, JULIUS FORRER, *Foreman*, } Tulare Substation, Tulare.
R. C. RUST, *Patron*, JOHN H. BARBER, *Foreman*, } Foothill Substation, Jackson.
S. D. MERK, *Patron*, J. H. OOLEY, *Workman in charge*, } Coast Range Substation, Paso Robles.
S. N. ANDROUS, *Patron*, J. W. MILLS, *Foreman*, } Southern California Substation, { Pomona. Ontario.
V. C. RICHARDS, *Patron*, T. L. BOHLENDER, *in charge*, } Forestry Station, Chico.
ROY JONES, *Patron*, WM. SHUTT, *Foreman*, } Forestry Station, Santa Monica.

The Station publications (REPORTS AND BULLETINS) *will be sent to any citizen of the State on application, so long as available.*

TABLE OF CONTENTS.

ILLUSTRATIONS.

REPORT ON THE CULTURE SUBSTATIONS.

THE FOOTHILL SUBSTATION.

(Five miles from Jackson, the county seat of Amador County, in the Sierra Nevada foothills; highest elevation, 1975 feet)

The last report of work done at this substation carried the history of the place from the summer of 1897 to the summer of 1899, covering two fiscal years. This report covers the period between June, 1899, and June, 1901, with some items, such as rainfall, continued to the latest date available before publication.

The foothill substation, while, as always, difficult of access and supervision, on account of the distance from the railroad, which must be left

PLATE 1. The New Pump-House and Workshop.

at Ione or at Valley Springs, is of growing importance to the district. Its collections of trees are large and valuable. Its experiments in many cultures adapted to the Sierra foothills have been many and useful. Its possibilities are great, and it will be many years before they can be considered to be exhausted. There has been a marked increase in the

horticultural interests of the region during the past five years, and the substation has done much to direct and develop this interest.

The plans arranged for in 1897 and inaugurated by the construction of a new cottage for the foreman at a cost of $900, which was practically completed by the end of 1898, have been carried out in the main as then decided upon. A larger turbine and pump, built by the Sutter Creek foundry, have been completed at a cost of $550 for materials and labor. A new and larger pump-house has been constructed, in which tools can be kept, a work-bench placed, the circular saws used in cutting wood, etc., stored, and work done in rainy weather. The circular saws and the grindstone are run by the turbine. The entire flow of the ditch can now be taken to give power. All that the water system needs to complete it is a large pipe from the pump to the reservoir on the hill. Breaks in the reservoir, due to faulty construction in 1889, have been repaired.

The old tank-house has been removed from the top of the hill and set behind the cottage on a good cement foundation. The ground has been properly terraced and walled wherever necessary near the cottage and the propagating-house.

The economic garden and areas for test plots near the cottage have been materially enlarged, and most of the small fruits placed by the water-ditch.

A separate building has been constructed for an office and seed-house, long necessary here. The cottage contained no room for these purposes, and it has always been desirable to have business headquarters, particularly at a substation which has so many visitors, forty or fifty persons having sometimes come in a single day. The office was built of mountain pine, covered with shakes, and battened, as cheaply as was consistent with durability. The size was 12 by 20 feet, and it was put on a rough stone foundation. The total outlay for labor and materials was less than $200.

Change in Officers.—Mr. J. W. Neal, who had served here as workman in charge and as foreman since June, 1897, was transferred to the substation near Paso Robles (his old home) in the spring of 1901, and Mr. John H. Barber was transferred from Paso Robles to the Foothill substation. The local Patron is still Judge R. C. Rust, whose interest in the welfare of the station remains unflagging.

CLIMATE.

The following brief table shows the temperature and rainfall at the substation from July, 1898, to June, 1901, inclusive:

Temperature and Rainfall at Sierra Foothill Substation for Three Seasons.

Month.	Max. Temp.	Min. Temp.	Mean Max. Temp.	Mean Min. Temp.	Mean Temp.	Rainfall.
1898—July	104°	50°	94°	64°	79°	trace
August	106	52	90	64	77	0.00
September	98	46	81	57	69	0.40
October	90	38	75	51	63	1.04
November	76	30	59	41	50	2.11
December	62	26	51	35	43	2.70
1899—January	68	26	52	39	45	5.20
February	70	20	56	38	47	0.57
March	72	30	56	38	47	14.60
April	94	30	77	43	60	1.49
May	100	34	74	44	59	1.07
June	96	44	84	58	71	1.00
Season 1898-99	106	20	71	47	59	30.18

TEMPERATURE AND RAINFALL—*Continued.*

Month.	Max. Temp.	Min. Temp.	Mean Max. Temp.	Mean Min. Temp.	Mean Temp.	Rainfall.
1899—July	96°	50°	86°	60°	73°	0.00
August	84	44	78	51	64	0.07
September	90	42	82	59	71	0.00
October	82	30	62	44	53	5.86
November	62	34	55	41	48	5.81
December	58	24	49	35	42	7.45
1900—January	58	28	48	37	42	2.37
February	58	30	48	37	42	2.15
March	64	32	55	41	48	4.37
April	66	32	53	39	46	3.57
May	74	36	64	45	54	1.83
June	82	42	72	52	62	0.06
Season 1899–1900	96	24	63	45	54	33.54
1900—July	94	50	83	60	71	0.00
August	96	48	80	56	68	0.00
September	88	42	77	48	63	0.41
October	80	32	67	45	56	2.74
November	76	34	62	44	53	8.32
December	66	20	50	33	42	2.24
1901—January	62	20	50	33	42	7.13
February	68	22	54	35	45	11.24
March	70	26	60	38	49	2.58
April	72	24	65	39	52	3.82
May	84	32	70	44	57	1.18
June	97	38	82	51	66	0.08
Season 1900–01	97	20	67	44	55	39.74

All these annual rainfalls are below the high average of the seven years before 1897, but are higher than for several previous years. The light and generally sloping and shallow soils of the foothills require a large rainfall to produce fair crops. Only once, in 1897–8, has the total rainfall of the season fallen below 20 inches since the substation was established.

Frosts, and Frostless Locations.—As the above table shows, the minimum in these three years has been 20° Fahr., which occurred in February, 1899, December, 1900, and January, 1901. The lowest recorded temperature at the station since 1889 was 16° Fahr., but this was at the ditch, the lowest point on the tract. The climate is an excellent one, well adapted to olives, figs, and, with care in choosing places in which to plant, to oranges. On the station tract, which varies 168 feet in elevation from the ditch to the top of the highest hill, there is a variation of from 4° to 6° Fahr. The climate varies very much according to elevation, exposure, and air currents, in all the surrounding region. There are many "early spots" being found and utilized by gardeners and fruit-growers, greatly to their profit, in this region, and the importance of location is nowhere more evident than here.

A change of less than 200 feet in the location of the small orange grove at the substation has materially improved the prospects of success with this fruit. Instances of this sort abound in the foothill country. A temperature of 20° Fahr. has not injured the orange trees here.

THE ORCHARD.

The previous report covered crops for the season of 1899. Several important problems are presented in the orchard which only time, patience, and careful observation can work out for this district. Attention will be called to these under the separate subheads.

POME FRUITS.

Apples.—This standard fruit has been given much care here, and the young orchards promise to be very valuable to this region. In 1899, the apple crop was fair, and twenty-four varieties fruited. In 1900, only four varieties fruited, and some of these dropped their fruit. Two varieties, Wolf River on slate soil and McMahon's White on granite soil, both early fall apples here, bore good crops. Clayton, on granite soil, was the only late-keeping variety to mature a crop. Transcendent Crab bore a large crop.

In 1901 the apple crop was chiefly borne by ten varieties, as shown in the following table:

BEST APPLES IN 1901.

Variety.	When Ripe.	Crop, in Pounds.
Hawthornden	Aug. 7	107
Violet	" 9	25
Wealthy	" 10	38
Wolf River	" 20	24
Acme	Sept. 20	20
Lady	" 30	25
Missouri Pippin	Oct. 10	69
Arkansas Black	" 10	26
Ingram	Nov. 15	20
Hyslop Crab	Aug. 14	35

There were many varieties of apples that bore a few pounds of fruit. In most cases the size was small. Gloria Mundi apples averaged a pound each; Wolf River, nine ounces. In quality, Violet, Wolf River, Missouri Pippin, Arkansas Black, and Ingram were good; Acme was distinctly poor.

The problem in the case of apples is evident here. They do not bear as well as they should. At about this elevation, 1,500 to 2,000 feet, there is considerable complaint that apples are shy bearers. The cause does not appear to be lack of moisture as a rule, for the trees make fair growth, and have healthy leaves. Deficient or weak pollination may be the reason in some cases. The dropping of immature fruit offers more difficulty. As the new orchards on different soils and exposures come to bearing age, this trouble can be more carefully investigated. It first appeared to any extent after the dry season of 1897–8, which doubtless had much to do with the present difficulty. It was less in 1899, but greater in 1900 and 1901. Successful apple culture for market in this district depends on conquering this weakness in respect to bearing. Higher up, between 3,500 and 4,000 feet, the apple bears as well as possible.

Pears.—This fruit promises excellent returns in this district, on suitable soil. Old trees on bottom lands near the creeks are of great size, and though unpruned and untilled, often bear large crops. The success of pears, if unirrigated, on the hill slopes depends on soil and culture. The original selection of very poor, thin, slaty soil near the entrance to the substation was a mistake, as none of those trees have thriven. The young pear orchard is on better soil. The pears on the mixed granite and slate soil have done fairly well.

In 1900, eight varieties of pears bore fair crops, namely, Doyenne d'Alençon, Keiffer, P. Barry, Duchesse d'Angoulême, Howell, Josephine de Malines, LeConte, and Mount Vernon. In 1901, the bearing varie-

ties were Bartlett, Columbia, Dr. Reeder, Keiffer, Nouveau Poitou, and P. Barry. A few fruits were borne by twelve other varieties besides these. The quality of the fruit was from fair to excellent. Dr. Reeder, a small, Seckel-like pear, was of the best quality. Bartletts were also first-rate, and Keiffer better than as ordinarily grown in the valleys.

PLATE 2. NEW ORCHARD AT FOOTHILL SUBSTATION.

P. Barry's keeping qualities were notable. Few conclusions respecting the failures of any other varieties can be drawn until the young orchard on better soil is in bearing.

Quinces.—There have been but few reports from this locality upon quinces. One rarely sees quinces in the old gardens, and then finds

them utterly neglected and usually pastured down by cattle, as often are apples and pears, into the condition of low, thorny shrubs. The quinces were set in 1889–90, on very light and rocky soil at the lower end of the pear orchard. Here even the olives are stunted. The four varieties—Rea's Mammoth, Angers, Orange, and Chinese—tested, have borne a few fruits for five years past and are improving in health and vigor. In 1901, the largest crop, 24 pounds, was on Rea's Mammoth; Chinese yielded 12 pounds.

Japanese Persimmons.—Previous reports have shown the entire adaptation of this fruit to the slate soil of the region. The trees are in much better and deeper soil than are the first plantings of pears and quinces. They bear very large crops, often all that the trees will carry, and are one of the most uniformly successful fruit crops at the substation. The persimmon attracts much attention, but its uses are less general than in the case of other fruits.

STONE FRUITS.

Almonds.—Previous reports have been decidedly against the success of this crop here, but the season of 1900 showed that when the late spring frosts are absent, the trees, now large and healthy, will give good returns. In those localities where the blossoms can be reasonably expected to escape—and such places exist here and there about this district—the almond can be made a paying crop, as the quality is unsurpassed.

In 1900, the blooming season ranged from January 15th to March 3d; Commercial and Harriott's Seedling being the earliest, and Golden State and Texas Prolific the latest. Late bloomers are preferable here, but Drake's Seedling and the old Languedoc, blooming quite late, are better bearers than the Golden State or Texas Prolific. The earliest to ripen are King's Softshell, Marie Duprey, and Nonpareil (July 28th); Texas Prolific, the latest, ripened August 24th. By ripening is meant the opening of the hull on the trees. The best bearers yielded from 14 to 40 pounds of hulled nuts per tree—the latter crop being that of Drake's Seedling.

In 1901, the spring frosts destroyed all the almond blossoms.

Reviewing five years, Languedoc and Drake's Seedling yielded well in 1897, 1899, and 1900, but were frosted in 1898 and 1901.

Apricots, whose history at the substations resembles somewhat that of the almonds, throve in 1900, when the crop averaged 50 pounds to the tree, large and small. Montgamet, Beauge, and Oullin's Early yielded 90, 100, and 80 pounds, respectively; while Moorpark and De Coulorge yielded 75 pounds each. The largest fruit on the substation is that of Montgamet.

Sardinian began to ripen June 13th; Oullin's, June 20th; Montgamet and Royal, June 25th; Moorpark, June 30th.

The spring frosts of 1901 destroyed the blossoms. As with the almonds, two years out of five the crop has been a failure in this location.

Nectarines.—The crop failed in 1901, owing to frosts; but in 1900 it was fair. The season began August 1st with New White, and ended August 30th with Victoria. The nectarine seems more easily frosted than the peach, and more resembles the apricot in this respect. It is usual to speak of the nectarine as thriving wherever the peach does, but this appears doubtful after the substation experience.

Peaches.—This is everywhere one of the most important of the foothill crops, and there is much land well adapted to its growth. In 1900, the flowering season began from February 25th to March 7th in different varieties, and lasted about ten days. The ripening period, that is, from first ripe to fully ripe, lasts from five to ten days.

The collection of varieties is now so great at the substation that we list only the best—those of high quality and bearing 40 pounds and upward per tree. They are arranged in order of ripening.

BEST PEACHES IN 1900.

Variety.	Ripening Period.	Crop, in Pounds.
Schumaker	June 22 to June 28	45
Governor Garland	" 23 " " 30	45
Ulatis	" 24 " July 3	50
Early Rivers	July 8 " " 15	70
California Cling	Aug. 8 " Aug. 19	40
Newhall	" 11 " " 18	45
Nichol's Orange Cling	" 19 " " 29	40
Newington Cling	" 22 " " 29	75
Columbia	" 29 " Sept. 6	70
Smock's Late Free	Sept. 4 " " 10	60
Beer's Smock	" 5 " " 10	60
Henrietta	" 10 " " 18	75
Salway	" 10 " " 16	100
Wager	" 15 " " 22	60

The peach crop in 1901 was not so heavy as in 1900, for all varieties suffered from frost, but it was a fair one. The early peaches, such as Alexander, Governor Garland, etc., suffered from depredations of thieves, and no exact record was possible. The bloom-period lasted from March 1st to March 10th. Excluding the small early varieties, the following table shows the results:

BEST PEACHES IN 1901.

Variety.	Ripening Period.	Crop, in Pounds.
Large Early York	Aug. 3 to Aug. 9	45
Honey Cling	" 20 " " 24	44
Elberta	" 21 " " 30	52
Newhall	" 26 " " 30	54
Mrs. Brett	" 28 " " 30	97
Muir	" 28 " Sept. 2	41
Morris White	Sept. 2 " " 10	104
Newington Cling	" 7 " " 10	86
Columbia	" 9 " " 12	60
Lemon Free	" 10 " " 20	65
Wilkins' Cling	" 11 " " 15	52
Salway	" 15 " " 27	58
Beer's Smock	" 15 " " 20	113
Crimson Beauty	" 18 " " 27	43
Garey's Hold-on	" 18	119
Henrietta	" 21 " " 28	72
Henrietta No. 2	" 25 " " 30	155
Wager	" 25 " Oct. 2	143

The most reliable "general crop" varieties in 1900 and 1901 were, named in order of ripening, Newhall, Newington Cling, Columbia, Salway, Beer's Smock, Henrietta, and Wager. One may add to this list for very early varieties, Governor Garland, Briggs' May, or Alexander, as preferred; we can also add Honey Cling for quality, and Morris White or Mountain Rose for a good, late white freestone. Henrietta, a fine late cling, is increasingly popular in the foothill region for canning, and Salway and Wager are standard freestones for the same purpose.

Wager, at the Foothill station has always ripened about a month later than Muir, and seems to be a better bearer.

In size, the peaches, with sufficient thinning, are fair, though not large. Henrietta and Wager maintain their normal size better than most other varieties do. A large number of well-known varieties, after years of testing, fail to grow and bear here as well as do the varieties listed and described above. With good cultivation and thinning, the peach trees have been healthy, and have borne high-class fruit for three years past, without irrigation, on either the slate or the granite soils. About one hundred and fifty varieties of peaches have been tested at this substation since its establishment.

Plums and Prunes.—The culture of plums and prunes in this district presents some especial difficulties. Every class of these fruits has been tested extensively on both slate and granite soils, with varying success, under different methods of pruning and culture, irrigated and unirrigated.

Nevertheless, the value of plums and prunes in this locality remains as yet an undetermined problem. In 1899, 1900, and 1901 about fifty-five varieties were in bearing here; but out of all of these only a few yielded more than 20 pounds per tree.

There are not many European plums which yield well or maintain a healthy growth here. Making every reasonable allowance for differences of soil and location, the Japanese plums, a few of the prunes, and two or three European plums appear to be all that have succeeded at this substation. The Japanese plums bloom so early that they are subject to frost. The few American plums planted here have not yet had thorough trial, but a complete collection of the Americans and crosses of Japanese are indicated by the situation. All the plums do better on slate soil than on the granite.

The following tabulation shows those varieties which came nearest to success here:

BEST PLUMS AND PRUNES IN 1900.

Variety.	Ripening Period.	Crop, in Pounds.
Burbank	July 23 to Aug. 7	150
Botan	Aug. 3 " " 10	45
Chabot	" 17 " " 30	40
Kelsey		30
Pond's Seedling (Hungarian Prune)	Aug. 17 to Aug. 27	25
Victoria	" 8 " " 16	30
Prune d'Agen (French)	" 18 " " 24	25
D'Ente de Puymirol	" 24 " " 31	25

The above list includes four Japanese and two European plums, also two prunes. Some crops were borne by Coe's Golden Drop and Robe de Sergent prunes.

In 1901, the varieties bearing well were as follows:

BEST PLUMS AND PRUNES IN 1901.

Variety.	Ripening Period.	Crop, in Pounds.
Burbank	Aug. 4 to Aug. 10	72
Kelsey	Sept. 1 " Sept. 10	18
Pond's Seedling	Aug. 24 " " 3	50
Victoria	" 27 " " 4	40
Columbia	" 21 " " 1	60
McLaughlin	" 2 " Aug. 12	25
Grand Duke	Sept. 5 " Sept. 15	40
Prince of Wales	Aug. 12 " Aug. 21	25
Prune d'Agen	Sept. 15 " " 25	63

In both these years, as in 1899, Burbank, Kelsey, Pond's Seedling, Victoria, and Prune d'Agen were among the list and were of very fine quality. The breakdown of European varieties here occurred between 1893 and 1897, during which years failures in bearing were general in plums of this class. Prunes also did poorly, but are now thriving much better than before. The plums and prunes present one of the most interesting of the many practical problems connected with this substation. Old and healthy plum trees are extremely scarce in the pioneer gardens of this region. Some good Petite d'Agen prune orchards are found in the neighborhood.

Cherries.—Previous reports on the gum disease and the failure of cherry trees at this altitude are still in the main true, but the three years, 1899–1901, show some improvement, as there has been more rainfall and less frost and the trees are stronger. The season in 1900 was from May 1st to June 15th for first ripening; in 1901, it was from May 5th to June 15th. Belle d'Orleans ripened both years long before Early Purple Guigne, a curious illustration of the vagaries of climate. Royal Ann was one of the latest. The best bearers in 1900 in red soil were Early Purple Guigne, 60 pounds; Bauman's May, 75 pounds; Coe's Transparent, 60 pounds; Napoleon Bigarreau, 65 pounds; and Belle d'Orleans, 40 pounds.

In 1901 the crop was smaller than in 1900, owing to late frosts. Many new varieties have not yet come into bearing. Some of them are entirely free from gum disease. The cherry is not largely planted in this region. A little lower down it does very well. At Sutter Creek, cherries ripen extremely early, and would probably command a good market on that account.

SEMI-TROPIC FRUITS.

The Fig.—There is no more promising fruit here than the fig. The avenue planted around Reservoir Hill when the station was established has thriven, and has very seldom suffered from frost or drought. In some important particulars this substation is the best one in California, and probably in the United States, for tests of figs. At Tulare many sorts are often frosted; Paso Robles is altogether too cold for the fig; at Pomona a great many varieties are subject to "fig sour."

Previous reports have listed the varieties being tested at this substation. In the spring of 1901 a new collection, including varieties of Capri and Smyrna, donated by Mr. George Roeding of Fresno, was planted here, and other new varieties are in the nursery, so that with the large Capri fig of the original importation, the breeding of the fig wasp can soon be undertaken.

In 1900, Black Marseilles, Brown Ischia, Gros Gris Bifere, and Monaca Bianca bore an early crop. Main, or summer, crops were borne by Black Marseilles, De Constantine, Dorée Narbus, Monaca Bianca, Agen, and White Adriatic. The last named, until the Smyrna types can be fructified, remains the best drying fig here.

In 1901, Breba, which often needs fertilization, bore an early crop; so did Petrovaca and Pastiliere. Good summer or main crops were borne by Abondance Précoce, Agen, Black Marseilles, Bourjassotte Grise, Cernica, Col di Signora Nero, Dalmatino, De Constantine, Dorée Narbus, Early Violet, Kargigna, Monaca Bianca, Pastiliere, Ronde Noire, White

Adriatic, White Genoa, White Ischia, and White Marseilles. These varieties bearing in 1900 and 1901 have generally proved the most reliable here.

Olives.—The crop of 1900 was the best ever known at the substation, and more varieties bore than in any previous year. This location is an excellent one for the olive; the trees are healthier and bear better than at any other substation. The avenues here, begun in 1889, and since extended, are well worth the study of every land-owner in the Sierra foothill region. Notes upon the frost-endurance of olives here and elsewhere appear in a separate article.

In 1900 the olive trees blossomed, according to variety, between May 17th and June 5th. The following table shows results where crop was 10 pounds or more:

THE OLIVES IN 1900.

Variety.	Soil.	Oil in Fruit.	Crop, in Pounds.
Amellau Amygdalina	Granite	Nov. 14	30
Atrorubens	Slate	" 20	45
Atroviolacea No. 1	Slate	" 5	35
Atroviolacea No. 2	Slate	" 5	70
Atroviolacea No. 3	Granite	" 6	27
Caillon Rubra	Granite	" 5	18
Columbella	Red		65
Corregiolo	Granite	Nov. 17	26
Lavagnino	Red	" 6	35
Leccino	Granite	" 4	5
Lucques	Red	" 15	70
Macrocarpa	Red	" 4	55
Manzanillo	Red	" 7	50
Manzanillo No. 2	Red	" 7	35
Manzanillo No. 3	Granite	" 9	11
Mission	Red		heavy
Mission No. 2	Granite	Nov. 10	10
Mission No. 3	Granite	" 15	11
Nevadillo Blanco	Red	" 7	30
Nevadillo Blanco	Granite	" 6	11
Nigerina	Red	" 8	15
Nigerina No. 2	Granite	" 7	35
Oblonga	Red	" 4	27
Pendulina	Granite	" 5	23
Polymorpha	Red	" 2	11
Polymorpha No. 2	Granite	" 3	23
Præcox	Red	" 1	28
Razzo	Red	" 6	16
Regalis	Red		55
Regalis No. 2	Granite	Nov. 10	11
Rufa	Red	" 3	40
Salonica	Red		80
Uvaria	Red	Nov. 1	45
Redding Picholine		" 4	60
Redding Picholine	Granite	" 6	45

Some of these yields are remarkable, such as that of Atroviolacea, Columbella, and Salonica. The yields of 10 and 11 pounds per tree come, in most cases, from younger trees than those of the main avenue.

Olives in 1901.—The bloom period of the olives in 1901 was between May 21st and June 10th. The hot dry winds of the late spring and early summer injured the blossoms, or the yield would have been, as a whole, fully equal to that of 1900. The pickling varieties which best withstood the winds were Macrocarpa and Mission No. 1 on the slate soil, and Polyantha on the granite. (There is no bearing Macrocarpa on the granite; the Missions usually do best on the slate soils.) The

best oil-producing varieties were, on the slate soil, Atroviolacea, Uvaria, and Lucques; while Pendulina and Caillon Rubra did best on the granite.

The crops yielded by the fifteen best bearing trees were as follows (in pounds): Mission No. 1, 78; Macrocarpa, 69; Atroviolacea, 57; Uvaria, 56; Redding Picholine, 46; Lucques, 38; Atrorubens, 36; Manzanillo, 31½; Polymorpha, 28; Præcox, 24; Razzo, 22; Oblonga and Caillon Rubra, 20 each; Rufa and Regalis, 18 each.

The foreman makes the just observation that Manzanillo "appears to be the best all-round olive here," having a fair crop every year, but doing best on the slate soil, as would be expected. Uvaria and Atroviolacea are to be recommended among the oil varieties, and Manzanillo and Mission among the larger sorts, used for pickling as well as for oil. The substation has for several years recommended these four varieties to planters here, and a great many trees have been set out, chiefly by the thrifty Italian land-owners.

Redding Picholine, besides being small and poor, bears very unevenly; some trees have no crop at all, while others are overloaded; it is not to be recommended. Mission No. 1 and No. 2, sent to the substation in 1889 by the late Mr. Klee, then Inspector, differ little from each other. Though one was thought to be much earlier in point of ripening, it has practically lost this advantage as the tree became older.

The manufacture of olive oil on a small scale has been carried on for two seasons, the machinery required being paid for by the surplus oil produced, and excellent samples of leading sorts and of blends being sent to the Central station and placed on exhibition.

Walnuts.—The quality of the walnuts grown here is notably high. The size of the nuts is not large. The trees do not always bear well, and so the exact place of this valuable crop in foothill orchards must be determined by further observations. Bijou bore 40 pounds in 1900 and 24 pounds in 1901. Santa Barbara Softshell yielded 20 pounds in 1900 and 48 pounds in 1901; Dwarf Prolific bore 19 pounds in 1900 and 34 pounds in 1901. Chaberte and Serotina are practically failures as regards bearing. Franquette, Vourey, and some other grafted trees of the best French varieties do not yet bear well.

The walnut, like the chestnut, merits long and careful experiments here, as both crops promise to be valuable. Though often shy bearers, so much depends upon the variety, location, and treatment, that the culture of both walnuts and chestnuts is difficult. The shrewd and careful Italians of Amador and adjacent counties who have had much experience in vineyards, are taking up olive culture and are showing interest in walnuts and chestnuts, as they also will in figs; so that a distinctive semi-tropic horticulture is being slowly developed here.

SMALL FRUITS.

The collections of small fruits here are large, and plants have been widely distributed in the district. Blackberries, raspberries, gooseberries, currants, strawberries, and other small fruits have received thorough tests. All require irrigation here. The common local method of applying water is wasteful, and false in principle, as it is simply run in shallow, open furrows at short intervals and no cultivation follows. Much less water, at longer intervals, with thorough subsequent culture, pro-

duces better results at less cost. Strawberries, raspberries, and blackberries are excellent here and easily produced. Currants suffer from sunburn, needing protection. Some gooseberries, notably the Oregon Champion, have done very well.

Blackberries.—Erie begins to blossom here about the end of April, and continues until early in June, grows well and bears heavily, ripening fruit from June 20th through July. Crandall has grown well, but is not, so far, much of a bearer. Ole Bull began to blossom about the middle of April, ripened from June 13th to July 18th (in 1900), crop medium, berries small. Early Harvest ripened fruit June 6th—not a striking growth. Kittatinny began to ripen June 18th, continuing to August; berries large, a good grower. Minniwasky, a berry received from El Dorado County under this name, ripened from June 21st to August, and yielded well. Cosumnes, a native Californian blackberry from the Sacramento Valley and a valuable stock for further crosses, began to bloom early in April, ripening fruit from June 16th to July 25th; quality high.

The Lucretia dewberry is excellent here. It requires a low trellis, either flat or upright. Ripened from June 7th until nearly August, 1900. All of the dewberries suit the district, and are a useful, hardy fruit, closely allied to the blackberry.

Raspberries.—Hurlbert usually blooms early in May, and bears well. Mammoth Cluster has bloomed April 20th, and ripened fruit June 11th. Golden Queen, French, Hudson River, Surprise, Marlboro, and Gladstone bloom about the same time, and begin to ripen within two or three days of the same date—about June 10th. All are excellent in quality. Many other sorts have been tested, but none are better than these.

Other Berries.—The Loganberry blooms here about the middle of April, and begins to ripen about June 1st. It is a very heavy bearer when trellised, and should be generally planted in the foothills.

The "Japanese Wineberry" is a strong grower and heavy bearer, but has no practical value.

The "Coralberry," "Muskberry," and "Mayberry," received from S. L. Watkins of Grizzly Flat, El Dorado County, have blossomed, but set few and worthless fruits. Like the "Wineberry," they should be discarded from the list.

THE VINEYARD.

An important part of the substation is the large vineyard, on both slate and granite soils, containing one hundred and fifty varieties of table and wine grapes. The local demand for cuttings of wine grapes is at present confined to those varieties which bear large crops. A good deal of wine is made for the local market, but very little finds its way elsewhere, and quantity is the main thing with all growers in this region. As transportation facilities improve, the making of better wines will attract more attention, and the fine collection of varieties at the substation will be more generally drawn upon.

The bearing quality of some varieties has improved with age and with changes in method of pruning. The foreman, Mr. J. H. Barber, furnishes the following interesting synopsis of his observations here, noting in parentheses the method of pruning which is best:

Varieties for Dry Red Wine.—Aramon (short pruning), Bastardo (half-long), Carignane (short), Grenache (short), Mataro (short), Mondeuse (half-long), Mourastel (short), Petit Bouschet (short), Tinta Val de Peñas (half-long). Preference for quality combined with bearing capacity should be given to Aramon, Carignane, Mataro, and Tinta Val de Peñas. Aramon is also a fine table grape for local use, and Tinta Val de Peñas a very acceptable one.

Varieties for Dry White Wine.—Burger (short pruning), Sauvignon Vert (short), Semillon (long).

Varieties for Sweet Wines.—Port type: Tinta amarella (half-long).

Sherry type: Palomino, or Golden Chasselas (short or half-long), West's White Prolific (short), Boal de Madeira (half-long), Mantuo de Pilas (short), Mourisco branco (short). Preference for quality is given to a mixture of two thirds Palomino and one third Boal; these varieties ripen at the same time. Palomino is a very acceptable table grape, as are also Mantuo de Pilas, Mourisco branco, and Tinta Amarella.

Cuttings of table grapes are in great demand, and the range of varieties wanted is much wider than in the case of wine grapes. A succession is desired, and quality counts for much. The substation, modifying, as experience dictates, previous lists, now recommends the following table grapes:

White.—Luglienga (July grape), Chasselas de Fontainebleau (sweetwater), Small Muscatel (Frontignan), Palomino (Golden Chasselas), Muscat of Alexandria, Huasco (which some prefer to Muscat), Mantuo de Pilas, White Tokay, Peruno, Pizzutello di Roma, Mourisco branco, Napoleon, Verdal, and Almeria.

Red.—Barbarossa, Flame Tokay, and Zabalkanski.

Black.—Tinta Val de Peñas, Cinsaut, Aramon, California Black Malvoisie, Tinta Amarella, Moscatello fino (Black Muscatel, a light bearer but of finest quality), Gros Colman (here of better quality than in the valley), Black Morocco, and Emperor.

The above list covers a season here of from July 25th until rains and frosts destroy the fruit, usually in November. Emperor and Almeria, picked and hung in a cool dry place, will keep until nearly Christmas.

The foreman further cuts down this list of table grapes, for home vineyards, as follows: "A good selection for the home vineyard would be the following: Luglienga, Aramon or Cinsaut, Tinta Val de Peñas, Palomino, Huasco, Mantuo de Pilas, Gros Colman, Pizzutello di Roma, Flame Tokay or Zabalkanski, Verdal. Of these, Luglienga, Pizzutello, and Zabalkanski should have long pruning; Tinta Val de Peñas and Palomino, short or half-long; the remainder, short. Luglienga and Pizzutello are good vines for arbors or trellises; in that case Pizzutello should be pruned to short spurs on long arms, as is the Mission when grown on an arbor."

There is as yet no demand for "shipping grapes" in this district, but when it comes, Flame Tokay will not be useful, as it bears poorly. Emperor, Mourisco branco, and Almeria promise better. There is only a small local demand for raisin grapes here. The quality is excellent, and the varieties planted are Muscat of Alexandria, Huasco, Thompson's Seedless, and Sultana. Muscats are to be pruned short; the seedless kinds are properly pruned long or half-long, according to soil.

TEST PLOTS AND SMALL CULTURES.

At no substation has a larger range of cultures received trial than at Amador. This was because the district was entirely new, and no farmers in the region were making tests of anything, but continuing to plant only a few staple crops, and a few varieties of these. Since 1889, therefore, the small cultures of the substation have been of much local interest. The following notes cover only the more striking results of this long-continued work, much of which is complete:

Saltbushes.—The experience with *Atriplex semibaccata* has now lasted four years. It has been planted in the field, on both red and granite soils, irrigated and non-irrigated, cultivated and not cultivated. If protected from the hares and squirrels, which are numerous and very fond of this plant, it grows, but no better than some other forage plants. It does not hold its own well on the hillsides with other plants, but its habit of early winter growth gives it some value here. It has done quite well on granite soil, plants here covering a circle of two feet in diameter. The hairy vetch seems much better adapted to this region, and is more easily naturalized in the pastures. Sheep, and as noted, wild animals, are extremely fond of the saltbush—more so than in valley districts, and it is worth growing on a small scale.

Atriplex leptocarpa (a trailing species), sown March 19, 1900, grew fifteen to twenty inches from the crown that season. It does not naturalize at all here.

Rhagodia spinescens inermis grows very large, three to four feet high, furnishes much fodder, and if started in boxes and transplanted to the rough hillsides, would afford much forage for animals. Its power of naturalization has yet to be determined, but plants do not seem strong.

Grasses and Clovers.—Bromus inermis (Hungarian brome-grass) has been thoroughly tested. It keeps green nearly all summer, without irrigation; should be sown early—say in November. Unless irrigated, the growth on either slate or granite soil is small—perhaps three or four inches in height. In September the top dies down, unless given water. A very little irrigation greatly improves it and lengthens its season. This grass appears to naturalize itself in favorable cases, and should be extensively sown.

A collection of ten varieties of evergreen and perennial rye-grasses from Sutton & Co., England, were sown in March, 1900. They grew from ten to twenty inches high, and were cut three and four times in the season. They were irrigated, and showed great value for small fields under ditch. Grown without irrigation, these grasses died out in summer. One of the best was the "Selected Perennial." When irrigated on red soil, Sutton's Perennial Red Clover grew to fourteen inches in height between March 1st and June 1st, 1900. It was thereafter cut three times. Red clover is a promising crop in this region, and sometimes grows twenty inches high by June 15th. Sutton's Giant Hybrid Clover, Perennial White Clover, and Yellow Trefoil were also grown, but only the first of them seems worthy of further trial.

Common White Clover (*Trifolium repens*), sown November 23, 1899, on granite soil, did poorly; on red soil with irrigation it did well.

Alsike, or Swedish Clover (*Trifolium hybridum*), is a very promising

clover for this region. With irrigation, it can be cut three times in a season, and has kept green until midsummer on granite soil without irrigation.

Egyptian Clover (*Trifolium Alexandrinum*) is a very promising crop. Seed sown November 23, 1899, on granite soil, without irrigation, grew sixteen and eighteen inches high and died down. An irrigated plot continued green all summer, started from the roots in early winter of 1901, and grew until midsummer. Unless irrigated, this clover must be resown every year; if irrigated, it will furnish very early pasturage.

The Common Snail Clover (*Trifolium turbinatum*) has been grown here for ten years. It covers the ground early, and if irrigated can be cut three times. Without irrigation, it begins to die down by the middle of June or first of July.

Beets and Other Field Roots.—There have been careful tests of all the leading field root crops, both with and without water, and on both granite and slate soils. These tests included carrots, parsnips, beets, turnips, etc., from the lists of Vilmorin, Sutton, Thorburn, Burpee, and other seedsmen. Early sowing is in all cases essential. With good cultivation, small root crops can be had on slate soil without irrigation. With irrigation, the crops are strikingly large. Beets, parsnips, and carrots do very well; turnips do poorly and have no place in the foothill farmer's rotation.

The great value of root crops for the farmers in this region deserves special emphasis. In the case of mangels from the best obtainable seed, Yellow Globe, with irrigation, yields at the rate of 30 tons to the acre; Mammoth Long Red at the rate of 43½ tons; Champion Yellow Globe at the rate of 72½ tons, and Red Globe at the rate of 54 tons. Some twenty sorts have received trial, and none have yielded less than 30 tons per acre. The Improved Kleinwanzleben deserves general use in this region. Irrigated once, and allowed to grow large for feeding, its sugar percentage would not be more than 8 or 9, but that is considerably more than in the case of Danish or of the various mangels.

Field parsnips have yielded at the rate of 40 tons per acre; White Belgian carrots did no better. There is need of more experiments with root crops in regard to best amount of seed to drill per acre, and many details; experiments until now have been with small plots. No fertilizers have been used.

Jersey Kale has been sown here three times. It grows very well on both granite and slate soils, and needs little irrigation, but requires protection from wild animals. A useful garden crop and new to this district.

Tagasaste has grown fairly well here, but failed on the hilltop when planted out to take care of itself; hence, it is useless here.

New Siberian Golden Millet has been grown twice here. Sown in November, it started badly; sown in March on red soil, it headed out May 30th when four feet high. An excellent hay crop. Seed distributed one season. Not equal to the broomcorn millets which were sent out by the Department of Agriculture, as elsewhere noted.

Buckwheats.—Six varieties from Berkeley, grown in plots in 1896. All kinds throve, especially the California and the Japanese. Sown again in 1899, the seed did not germinate.

Flax.—A collection of flaxes has been grown here, attracting much attention. The varieties were California, Royal (from Germany), White Flowering (from France), Belgian Improved, Russian Pskoff, Pure Riga, White Dutch, and Yellow Seeded. Sown November 23, 1899, these varieties began to bloom April 18th to 23d. The height of Royal was 30 to 36 inches; of Belgian, 36 to 42 inches; and few plants of any variety were below 25 inches. The fiber was excellent, and the seeds plump and bright.

Lupins.—Experiments with lupins for green-manuring have been followed for several years at this substation. In some seasons the results have been very promising, but in others less so. On the whole, the prospects of practical results valuable to the farmers of this region are improving.

European Yellow Lupin, sown November 6, 1899, in eighteen-inch drills, seed dropped ten inches in the rows, soil mixed slate and granite, made plants six inches high by March 15, 1900. Did not cover the ground. Sowed too thinly, but previous thick sowing had made the plants slender.

Large Blue Lupin, under similar conditions, grew sixteen inches high, and was in full bloom March 16th, but the foliage was light and tubercles scant.

Large White Lupin reached a height of seventeen inches, with heavy foliage and wide spread of branches, by March 15th. The ground was fairly well covered. This lupin was in full flower by March 12th.

The Large Rose Lupin grew taller, but more slender. The common European Blue did poorly. *Lupinus tricolor* was a failure, and *L. angustifolius* little better.

In 1900–1901, the lupins suffered much from squirrels and hares; but being sown early and the season being mild, they grew larger than in the previous year, affording good covering to the ground and making a profitable fertilizer. The large lupin plots have been fenced with wire, which measurably keeps out depredating animals, and the area devoted to this culture has been extended on poor soil which needs fertilization. The Large European White Lupin appears to be the best variety to plant in this locality.

SEEDS FROM THE DEPARTMENT OF AGRICULTURE.

The following notes are chiefly upon plants the seeds of which came under numbers from the Section of Seed and Plant Introduction of the Department of Agriculture. Some notes on the same species otherwise obtained are included.

Muskmelons.—Nos. 1117, 1118, 1140, 1142, 1144, 1145, 1147, 1148, and 1208 were planted in the spring of 1900 on red soil. Growth was not strong, and all varieties set poorly. No. 1118 was a delicious, green-fleshed melon, weighing 4½ pounds to the average fruit. The late or winter varieties did not seem desirable for home market.

In 1899 a large collection of Turkestan muskmelons from Bokhara and Amu Daria were grown (Nos. 124, 125, 126, 127, 129, 130, 132, 133, 139, 141, 145, and others). The quality of these melons was poor and none of the vines bore well. Seeds of a few of the more promising were distributed for further trial elsewhere.

It appears necessary to irrigate all melons once or twice here, to produce good crops on the hill-slopes. Melons do well on some of the bottom lands without any irrigation.

Stock-melons.—The Khama stock-melon from South Africa, so successful at the substation in southern California, did but poorly here. The Kansas stock-melon also failed to bear well. This crop is not adapted to the district.

Watermelons.—Always of very fair quality here; the crops on this soil are light, and the fruit small. The leading varieties known have been planted.

Vetches.—Many kinds of vetches have been tested here, in past seasons, some from the Department of Agriculture, others directly imported from Vilmorin and others. *Vicia ervillia*, the black bitter vetch from France (No. 1452), sown December 3, 1900, grew from twenty to twenty-five inches in length of branches, and blossomed throughout May. Considered a valuable vetch in Algeria. Yield not equal to that of *V. sativa* here.

The Kidney Vetch (*Anthyllis vulneraria*) (No. 1503 of the Inventory) was grown here in 1896, when this "yellow sand clover" did fairly well on granite soil, making sparse foliage. Again sown in November, 1899, on both granite and slate soils, it did very poorly, growth stopping when hot weather came.

Vicia sativa, or common Spring Vetch (Nos. 1504 and 1505 of the Inventory), and also *V. sativa cordata*, have been grown, the former for several seasons. They require sowing as early in winter as possible, and will then make a heavy spring growth on both granite and slate soils. They stand the hot weather quite well. Department seed of *V. sativa cordata*, sown November 23, 1899, began to bloom May 17th on the granite soil and June 6th on the slate. *V. sativa*, sown on same day, bloomed May 20th on the granite and June 13th on the slate soil. Its yield was heavy, and it can be strongly recommended to farmers as an excellent forage plant here. *V. sativa cordata* did better than the ordinary form.

No. 1507, the white variety of *Vicia sativa*, did but poorly when compared with *V. cordata*, as reference to the table will show. An irrigated plot on red soil grew 4 feet high, blossomed throughout June, and exemplified the profit of using water where available.

Vicia macrocarpa (No. 1508), a massive, large-leaved species, did very well on two trials, and is worthy of further planting; as also is *Vicia narbonensis* (No. 1509), which on slate soil yielded heavily and is one of the best annual vetches tested at this substation. The main sowings of *V. narbonensis* were November 6 and November 23, 1899. It failed on the granite soil.

Another promising annual vetch, but only for the slate soil, is *V. fulgens* (No. 1514), from Algeria, a showy and useful species. Both this and *V. narbonensis* reached a height of 3½ to 4 feet on the slate soil. The bloom period of *V. fulgens* has begun as early as May 17th and as late as June 13th. It appears especially well adapted to these hillside pastures, and is highly recommended by Dr. Trabut of Algiers.

The "Narrow-leaved Vetch" (*V. angustifolia*) (No. 1511), sown

in November, blossomed May 26th on the granite and June 15th on the slate soil. The yield was not large.

Vicia atropurpurea, sent from Berkeley in 1899, sown November 23d, blossomed May 22d on the granite and June 15th on the slate soil. It grew 2 and 2½ feet high, and yielded a medium crop. Under similar conditions, *Vicia peregrina* did not do so well. *Vicia Bythinica* proved a promising species on both soils.

But the most useful species tested at the substation seems to be the old *V. villosa*, or Hairy Vetch, perhaps because its culture has been carried on since 1890 and it is now somewhat naturalized on the hillsides. Seed has been sent from Berkeley several times, and has also been gathered at the substation. The last sowings, November, 1899, were on both soils. On the granite, this vetch blossomed May 10th; on the slate, June 1st. The growth was "thick-matted" and 6 feet from the crown on either side. A plot sown broadcast with Russian rye blossomed June 4th (poor granite soil). The rye germinated badly; the vetch yielded better than any other crop ever put on this soil. Hairy Vetch is extremely well adapted to this region, can be naturalized in pastures better, it would seem, than the Australian saltbush, affords more fodder, and justifies much more extensive trials.

Hairy Vetch, sown broadcast November 7, 1900, on mixed slate and granite soil (but light and poor), came up thickly, made 2 to 4 feet growth from the crowns, and blossomed in May. Used as pasture on pure granite soil, it did nearly as well. Sown on similar soil March 2, 1901, it grew 10 feet from the crowns, and bloomed in June. Sown too late for best results.

The following synopsis shows the yield of the best of these different vetches in 1900:

Name.	In Full Bloom.	Yield per Acre, (Green), In Pounds.
Vicia peregrina	June 4	14,620
Vicia atropurpurea	" 4	17,240
Vicia fulgens	" 4	18,150
Vicia Bythinica	" 5	19,057
Vicia narbonensis	May 25	25,400
Vicia sativa	June 4	25,410
Vicia sativa cordata	" 4	30,855
Vicia villosa	" 4	32,670

In previous years (1895 and 1896), small plots of *Vicia villosa* have yielded on red soil, unfertilized and unirrigated, at the rate of 20 tons of green fodder per acre. The experiments thus far indicate that *V. sativa*, *V. sativa cordata*, *V. narbonensis*, and *V. villosa* lead all others in practical value here, and of these *V. villosa* seems best adapted to the district.

Lentils.—No. 1346 (a Russian variety), No. 1466 (the small queen or March lentil), No. 1467 (the red winter lentil), and No. 1483 (the one-flowered *V. monantha*) have been grown here. In addition, the "Big Hiller Lentil," from Russia, and a collection of lentils from Vilmorin, were planted. All of these received several tests on both soils. Lentils sown early are well adapted to the red soils of this district, though as yet but slightly known. Sown early in November, they bloom early in May. Nos. 1466 and 1467 grew 1 foot high and spread 2½ feet in the rows. Crop excellent. No irrigation is needed. The granite soil produces little.

One plot of No. 1483, the one-flowered lentil, sown December 3, 1900, made a growth of 2½ to 3 feet in length of vines, blooming May 15th. Crop excellent.

Turkestan Alfalfa.—The Department of Agriculture sent, in the fall of 1898, and again in 1899, Nos. 1150, 1151, 1159, and 1169 of the alfalfa (*Medicago sativa*) known as *turkestanica*. As at both Paso Robles and Tulare stations, this alfalfa seems hardier and more drought-resistant than the common variety, but yields no better. There is no appreciable difference among these lots of Turkestan alfalfa. None of them have seeded well.

At Amador substation the plot suffered much from squirrels and hares, which climbed a three-foot wire netting. Close measurements of results are impossible here until the entire station tract southwest of the ditch is fenced against these animals.

Turkestan alfalfa blossoms here about May 15th, when it is 14 to 15 inches high, without irrigation, on mixed soil; and when 18 to 20 inches high on the slate soil. One irrigated plot reached, by June 15th, a height of about 26 inches, and, being protected from animals, was cut three times (season of 1900). The above plots were sown in November. Plots sown in March did not bloom until June 16th, but made three cuttings and were nearly as large as that sown in November.

This lucerne from central Asia possesses a large root system. Its leaves are more pubescent, and in the dry season they turn more edgewise toward the sun. Hence the plant exhales less moisture. Under irrigation, these features are less marked.

Cuzco Maize.—The large-seeded, tall *Zea mays* from Bolivia (Nos. 758 and 759) failed to mature here. It requires irrigation. The kernels are hardly half-ripe when the frost comes.

Velvet Bean.—The "velvet bean" (*Mucuna utilis*) received from Florida was grown in 1898. It made a very poor start, and did poorly, needing more moisture. Bears no comparison with the vetches.

Safflower.—The well-known safflower, *Carthamnus tinctorius* (No. 1345 of the Inventory), was grown in this region years ago, and occasionally appears in old gardens. Since tested on the substation, it proves very easy of growth on both soils, very drought-enduring. Does not compare with the Russian sunflowers as a yielder of seeds for oil or chicken feed. Sunflowers are healthy and of the easiest culture here.

Artichokes.—Several collections of *Cynara scolymus*, including Nos. 1364, 1365, 1366, and 1367 of the Inventory, have been grown here, with irrigation, and give excellent results. Degenerated artichokes run wild on the hill-slopes, are sometimes found in this region, but "go to seed" in early summer. Offshoots have been locally distributed.

Cotton.—The Peruvian cotton (No. 1363) proved too late a species to mature here. Collections of cottons from Georgia and elsewhere have been grown on several occasions, and the ordinary upland varieties mature well here, are healthy, and make a medium growth without irrigation, on the red soils; on the poorer granite soils they have failed entirely.

March Rape.—This quick-growing form of the common field rape (*Brassica napus*) (No. 1449 of the Inventory) has been one of the most promising plants for quick-growing forage ever tested on light granite soils. It must be sown early in November, or with the first rains, and will grow all winter. This and the Essex Rape are recommended by the station for more general trial in the Sierra foothills, but the March Rape does better than the Essex. It should be sown in drills, on well-prepared soil, at the rate of two pounds per acre, or broadcast at the rate of five pounds. If the land is very poor so that plants do not branch much, it should be sown even more thickly than this. But on the granite soil at the substation, rape has covered the surface, growing three to four feet high, and yielding at the rate of 32 tons of green fodder per acre. As this is land which will hardly produce half a ton of cured barley hay per acre, the value of the crop is evident. March Rape sown on slate soil yielded at the rate of 47 tons of green forage per acre.

If the winter is cold and wet, rape can be drilled on raised furrows, to allow an earlier start. It is valueless here for summer pasture. The growth of our wild mustard and turnip, which start with the first rains, afford a clue to the proper place of rape on foothill farms.

Sulla.—This perennial legume (*Hedysarum coronarium*) has been tested on both soils since 1891. It stands the climate well, but fails on the granite. On the slate soil it grows three feet high. It shows no inclination to naturalize itself on the hillsides, and often needs some irrigation to carry it through the summer.

Garbanzo.—This, the "Pois chiche" of France, corrupted to the "chick pea" of catalogues, and called by some seedsmen "Idaho pea," is well known in California as "Garbanzo," a common table vegetable. Seed was received under the Inventory numbers 2139 and 2376. Sown December 3d on slate soil, it was eighteen inches high June 15th, and did fairly well without irrigation. If watered, it makes a large growth. The late spring sowing recommended elsewhere is not satisfactory here.

Broad Beans.—All the leading varieties of *Vicia faba* have been tested here. A collection from Sutton & Co., and one from Vilmorin were planted, also Nos. 2064, 2065, 2066, and 2375 of the Inventory. The best of the last-named in point of growth was No. 2375, the "Windsor." All these English or broad beans are hardy here, require sowing with the first rains on slate soil, and yield heavily without irrigation. A profitable crop for the farmers. The table use of this bean is only to be seen among Portuguese families.

Field and Other Peas.—Victoria field pea (No. 1173), from Moscow, originally an English variety, was tested in 1899 and 1900. Sown in November, it grows but slowly and not large. *Lathyrus sativus* (No. 1175), cultivated in the Volga River provinces, is a bitter vetch used "in moderation with coarse fodder" (Inventory No. 2, U. S. Div. of Botany). Too freely used it is injurious. It grew but poorly at the substation. Nos. 2120 and 2121 were edible-pod peas of good quality for the table. The "gray field peas" (*Pisum arvense*) (Nos. 1485, 1486, and 1487), sown in drills, made fair growth, but were not equal to the best vetches.

GLUTEN WHEATS.

Experiments with the so-called "gluten wheats" have continued for two years here, as at other substations. The following notes show yield on small, drilled plots, in the season of 1900–1901:

Theiss (No. 3823), from the original stock, sown November 30th on granite soil, grew three feet high, and was cut July 8, 1901. It only yielded at the rate of 198 pounds of grain per acre. Seed of this original stock, harvested at Tulare substation in 1900, sown on this soil, yielded in 1901 at the rate of 340 pounds per acre. Seed harvested in 1900 at Amador, yielded in 1901 at the rate of 11,041 pounds of hay per acre. This plot was on slate soil, and fertilized with nitrate. Unfertilized, it yielded at the rate of 10,729 pounds per acre. The light granite soil hardly makes any grain here, and only a very small crop of hay, even in years of greatest rainfall, unless fertilized.

Fultz wheat, original stock (No. 5493), sown on granite soil November 30, 1900, yielded at the rate of 214 pounds per acre. One third of both the Fultz and the Dawson were destroyed by squirrels.

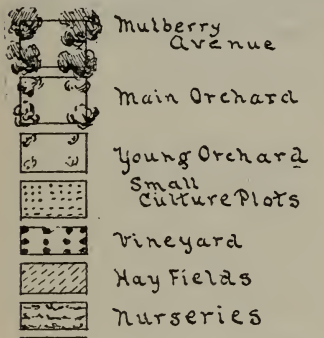
As these hard wheats are grown at this substation in successive generations from the original, the kernels become more puffed up, lighter in color, and show an increasing layer of starch. The plants spread less on the surface when small, and the yield of grain is greater. The original wheat seems to hold its own less here than at Tulare.

SOUTHERN COAST RANGE SUBSTATION.

(One and a half miles north-northeast from Paso Robles, San Luis Obispo County. Elevation, nearly 800 feet.)

There have been several changes at this substation since the issuance of the last report. The Patron, Mr. F. D. Frost, resigned in 1900, and his place was taken by Mr. S. D. Merk. Mr. J. W. Neal was transferred here from the Amador substation in 1901.

History.—The substation near Paso Robles was one of the three first established, and has cost more in proportion to positive results than any other of the outlying substations. It was located upon soils typical and varied, in the oak country east of the Salinas River, in a region which was at that time (1888) just changing from long-continued pastoral conditions and the large Spanish ranches of pioneer days, to small farms and modern agricultural problems. Long-delayed currents of life overflowed the region, and large sums of money were wasted by the settlers on crops unsuitable to the soil and climate. If the substation had been established even five years earlier, it might have been able to prevent a large part of these losses; or if it had been established five years later, the experience of others would have been a useful guide to early substation investments. As it was, the history of the place is very closely linked with that of the community; and as will be seen in a bulletin on "Deciduous Fruits in the Upper Salinas," the work of the substation has been by necessity extended over a large area. Other notes upon the recent work of this substation will be found in an account of the Australian and other saltbushes.



LEGEND FOR CHART 1897–8. (See next page.)

At the time that the substation was established, the entire upper Salinas country from San Miguel southward, was taking strong hold of fruit-growing industries, expecting to follow in the footsteps of the Santa Clara Valley in the matter of prunes, apricots, peaches, grapes, and even, as some writers then maintained, olives, oranges, lemons, walnuts, and figs. An ample experimental orchard and vineyard were therefore established, and as different varieties failed others were tested, from year to year, until between 1889 and the present time almost every variety and certainly all types of deciduous and other fruits that offered any

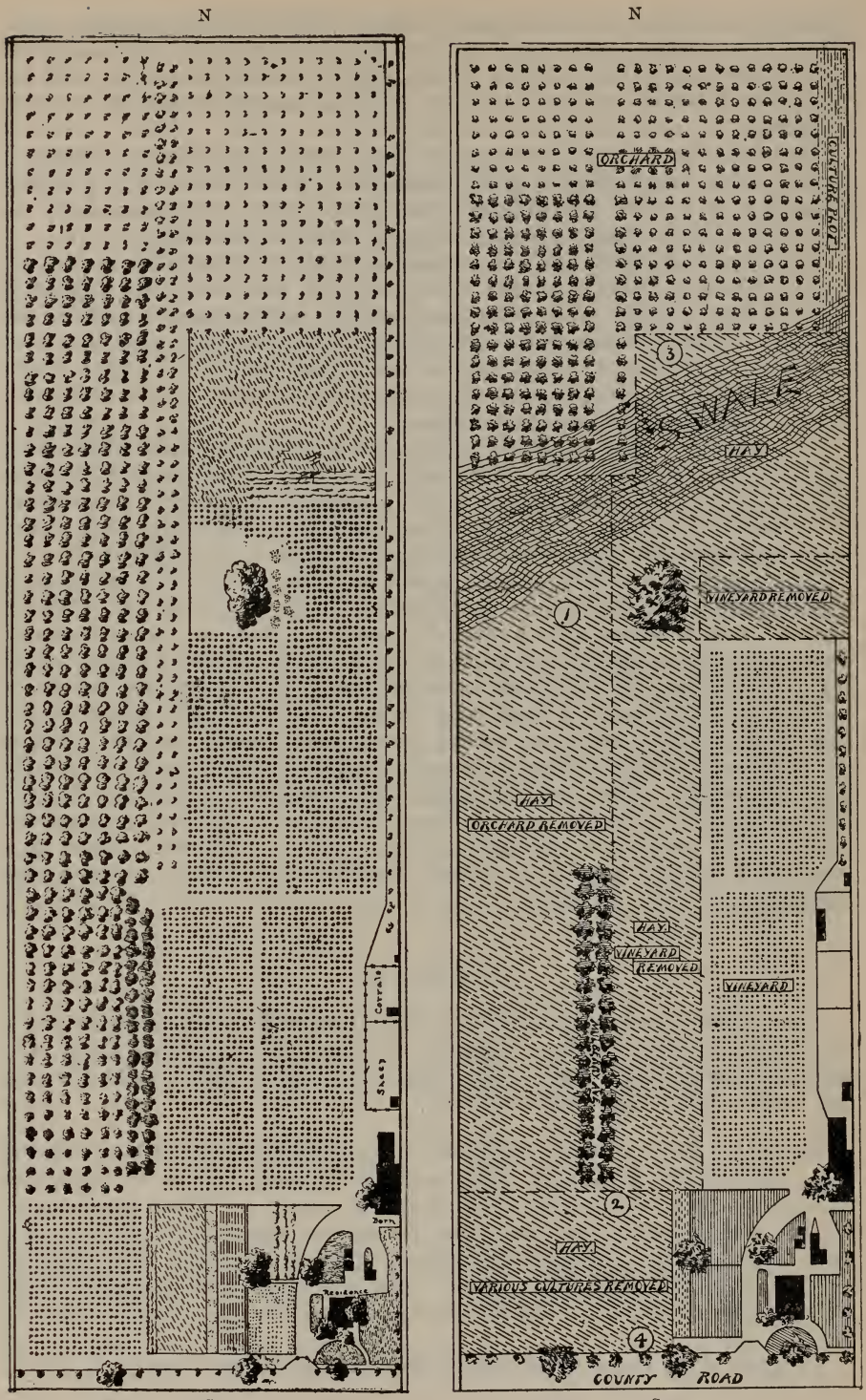


PLATE 3. CHARTS OF SOUTHERN COAST RANGE SUBSTATION.

prospect of success have been grown here. The last large planting consisted of an orchard of several hundred selected varieties of apples, pears, and other hardy fruits, which is not yet in bearing, but soon will be. The labor of years in these lines has yielded some very valuable positive results.

From the time that the substation began work, there have been experiments with forage plants and grasses and with whatever vegetation promised to endure the difficult climate and the poor soil. Some of these have given positive results of great value to the region.

A continuous effort has been made to obtain trees and shrubs whose root systems or habit of winter growth is such that they will penetrate the hardpan, which on a large part of the substation soils offers the greatest obstacle to successful agriculture. This hardpan area has been mapped, its thickness measured, and its nature studied. There is much of such soil in California, and the crops possible upon it are often still further limited by climatic conditions.

The years of light rainfall which have occurred since 1888 have enabled the substation to make some important and indeed unique records for maintaining plant growth in seasons of drought. In seasons of sufficient rainfalls, the very complete tests of cereals and many cultures made here have been of recognized value to the district.

The conditions which prevail over a large portion of the area east of the Salinas River, known as the Estrella plains, in San Luis Obispo County, now indicate a wise tendency toward larger, not smaller farms, and toward the pastoral use of much land which has been proven unfit for horticulture. The substation's greatest future usefulness lies in its securing a larger area of land, and there planting those forage plants and those shrubs and trees which have been shown to succeed here, so as to make the pastoral side of its work more important and more nearly self-supporting. The area along the upper Salinas subject to irrigation is very limited; it is the vast rolling plains and uplands east of the river which constitute the agricultural problem of to-day. Here, also, continued experiments with cereals, particularly with new cross-bred varieties, are very desirable.

CLIMATE.

The record of temperature at the substation now covers thirteen years; the rainfall record has been kept for this district for sixteen years, and more or less accurate notes upon climate during an earlier period, reaching back to 1850, have been secured.

Record of Trees.—Three large oak trees growing near the substation were cut in 1899, 1900, and 1901, and the rings of growth examined to determine the probable nature of previous seasons. These grew on the rolling plains east of the river, and the species was *Quercus lobata.* All three were mature and growing trees ranging in age from two hundred to two hundred and fifty years. One specimen was decayed in the middle, and thus part of the record was destroyed. All stood on nearly level land.

In these three trees the annual rings of wood varied greatly in thick-

ness. All showed years of excellent growth, years of medium growth, and years of very scanty growth. In all three, rings of wood of more than average thickness were deposited for one and occasionally for two seasons after the following winters: 1841–2; 1849–50; 1861–2; 1875–6; 1879–80; 1888–9; 1892–3. The periods of smallest wood growth corresponded very closely with the following seasons: 1840–41; 1847–8; 1851–2; 1863–4; 1870–71; 1882–3; 1893–4; 1897–8. Still earlier, there were records on these trees of several years when hardly any wood was deposited, the inference of course being that these years were extremely dry and cold. One such period showed on all three trees, closely following 1795; a much longer and more severe period showed on two of the trees (record of the third destroyed) from 1744 to 1756. From twelve to fifteen extremely thin rings, hardly thicker than the point of a pin, marked this period of tree suffering. Two or three very dry seasons in this decade would have been enough to check growth for a long time, and other natural causes may have been in operation.

The checks to growth caused by such dry seasons as 1863–4 (a very plain record) extended over four and five years. The growths of the two seasons following 1861–2 were collectively greater than those of the six years which came next (1863–4 to 1868–9).

Since the three trees which were examined agree very closely with each other and with the climate record, so far as known for this region, it is fair to conclude that the record for earlier years is no less accurate.

Rainfall and Temperature.—The rainfall does not materially differ over a large area of country east of the Salinas, except that it lessens somewhat as one goes from the river toward the San Joaquin Valley, and increases in the mountains north or south of the broad, rolling plateaus, such as the Estrella or the Carrisa plains. There is little difference in rainfall between Paso Robles and the substation, but what advantage exists is in favor of Paso Robles, at the base of the Santa Lucia range.

At the substation, the season's rainfall has four times since 1888 exceeded 20 inches. The average of fifteen years' rainfall (Paso Robles for 1886–8 and the substation for 1888–1901) is 16.28 inches. This is a very satisfactory average, although averages of rainfall, like means of temperature, must not have too much dependence placed upon them. The following table gives the rainfall by months for four seasons:

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	Totals
1897–8	.03	.56	.05	.23	.82	1.55	.83	.00	.68	4.75
1898–9	.10	.13	.30	.27	4.16	.08	4.99	1.37	.00	11.40
1899–00	tr.	2.55	1 40	2.55	2.11	.08	1.90	.42	.67	11.68
1900–01	tr.	1.54	6.10	.25	6.11	5.37	.63	1.37	1.43	22.80
Average	.03	1.19	1.98	.82	3.30	1.77	2.08	.79	.69	12.65

While the average yearly rainfall for the four years from 1887–8 to and including 1890–91 was 21¼ inches, or enough to justify the highest hopes of success with a wide range of crops, the yearly average for the past four years, as shown in the above table, was less than 13 inches. To be accurate, the average annual deficiency, comparing these two periods, was 8.60 inches against the last four years. The average of fifteen years' rainfall here was a little more than 16 inches, and even

this is 5 inches better than the average of the past four years. It is therefore reasonable to expect somewhat better seasons.

The early and late frosts which injure or destroy crops otherwise desirable for this district, must be reckoned with by every practical man. The isotherms, or lines of equal heat—mean annual degrees of warmth—are of comparatively little importance to the farmer; it is the extremes of temperature, daily and seasonal, which are all-important. A maximum of 98° Fahr. and a minimum of 22° Fahr. make the same mean of 60° that is given by a maximum of 107° and a minimum of 13°, but the difference in the resultant vegetation of the two districts is very great.

The lowest temperatures recorded in this region were in 1878, 1886, 1887, and 1888, at Paso Robles and San Miguel (railroad records), when the thermometer once fell as low as 13° Fahr., and several times to 16° Fahr. The substation records show that fruit crops were more or less injured by frosts in nine out of thirteen years. The worst frosts come in March and April, in which months there are often fifteen "killing frosts." In 1892–3 there were forty-two, and in 1898–9 twenty-eight such frosts. The frosts of January and February do little or no harm to fruit. But frequent warm days in February bring out the blossoms early in March, so that anything below 34° Fahr. then injures or destroys almonds and apricots, while anything below 32° Fahr. sweeps off the cherries and peaches. It is of course the April frosts that are the most deadly.

"Smudging" has been experimented with in every form, but proves of no value here where the frosts are so prolonged and so severe over so large an area of rolling country. The total "subject to frost" period has ranged from 200 to 242 days, in the latter case extending from September 21st to April 20th. Irrigation on a small scale, around a few trees, the use of straw on the surface, whitewash on the trees, and every other suggested method of retarding the blossom period of fruit trees failed to have an appreciable influence against the high February maxima of temperature.

The following table continues the record given on page 281 of the last report (for 1897–8):

Temperature Statistics, 1899–1901.

Month.	Daily Mean.	Mean Daily Max.	Mean Daily Min.	Mean Daily Range.	Extreme Max. and Dates.	Extreme Min. and Dates.
1899—July	70.22°	89.00°	51.45°	37.55°	102°—10th	45°— 7th
Aug.	65.59	80.29	50.90	29.39	88 —28th, 29th	44 —16th
Sept.	69.20	88.10	50.56	37.54	97 —13th	44 — 6th
Oct.	58.80	70.58	47.03	23.54	93 — 8th	39 —29th
Nov.	54.35	62.73	45.96	16.76	69 —13th	37 —27th
Dec.	47.29	59.77	34.83	24.93	67 —24th, 25th, 26th	25 —28th
1900—Jan.	49.80	60.96	38.64	22.32	69 —18th, 19th	28 —11th
Feb.	50.28	65.35	35.10	30.39	77 —17th	27 — 8th
Mar.	57.12	71.41	42.83	28.58	82 —30th	32 —28th
April	53.26	68.93	37.63	31.30	87 —17th	27 — 9th
May	64.38	82.03	46.74	35.29	96 —21st	40 —11th, 25th
June	68.50	86.50	50.53	35.96	99 —19th, 20th	43 —15th
July	70.22	90.51	49.93	40.58	106 — 8th, 9th, 12th	45 —22d
Aug.	67.12	84.06	50.22	33.83	110 — 2d	42 — 9th
Sept.	63.33	82.13	44.13	38.00	100 —22d	36 —25th, 26th
Oct.	59.67	74.93	44.77	30.19	90 — 9th	27 —30th
Nov.	56.23	71.13	41.36	29.76	87 —12th	31 —13th
Dec.	45.58	59.64	31.54	28.09	71 — 6th	18 —31st

TEMPERATURE STATISTICS, 1899–1901—Continued.

Month.	Daily Mean.	Mean Daily Max.	Mean Daily Min.	Mean Daily Range.	Extreme Max. and Dates.	Extreme Min. and Dates.
1901—Jan.	46.61	57.03	36.22	20.80	68 —19th	17 — 1st, 2d
Feb.	50.85	60.60	41.10	19.50	74 —28th	24 — 7th
Mar.	52.70	66.90	38.51	28.38	78 — 1st	29 —29th, 31st
April	53.76	70.46	37.10	33.36	84 —19th	28 — 7th, 8th
May	60.54	75.90	45.22	30.67	94 —31st	36 —20th
June	66.43	87.26	45.60	41.66	110 —28th	36 —10th, 13th
July	73.64	94.87	52.74	43.74	106 —19th	44 — 3d
Aug.	72.29	92.32	52.25	40.06	109 — 2d	40 —24th
Sept.	63.03	82.43	43.63	38.80	98 —16th	36 — 8th
Oct.	62.99	80.48	45.41	35.06	96 —13th	36 — 2d
Nov.	54.60	67.40	41.83	25.53	83 — 5th	32 —13th
Dec.	44.74	60.35	29.12	21.22	68 —31st	16 —13th

The number of "killing" frosts during this period was as follows: From December, 1899, to April, 1900, inclusive, thirty-six; from October, 1900, to April, 1901, inclusive, forty-seven; November and December, 1901, twenty-two. The total for the two years was one hundred and five, and in January, 1902, there were twenty-two more.

The temperature record has been kept at this substation since it was established, and with a maximum and minimum thermometer, and in recent years a self-recording instrument. Orchards and gardens here and there escape frosts; one notable Paso Robles case is that of Mr. Brentlin, half a mile from the substation, on a northeastern slope. West of the Salinas, in the foothills, are many locations which appear to be frostless, but a great deal of the region east of the river, and not a little west, is subject to late spring frosts. It will take years of close observation to determine with any certainty the "frostless areas"; but only by doing this can the "safety points" be ascertained for many kinds of fruits.

THE ORCHARD.

The history of the orchard has been fully set forth in a separate bulletin entitled "Experiments with Deciduous Fruits at and near the Southern Coast Range Substation from 1889 to 1902." It is only necessary, therefore, to give some observations which do not appear in that bulletin. These refer principally to the very promising young orchard planted in 1897 at the northern end of the substation on both the brown and the black adobe soils beyond the swale.

Apples.—In the young orchard, Ivanhoe, Terry, Eureka, Gold Ridge Winter, Swaar, Red June, Seek-No-Farther, Duffy's Seedling, and Bethlemite bore for the first time in 1901. All of these, excepting Red June and Swaar, are new to this district and to the substation.

The best of all these varieties is Gold Ridge Winter, a California seedling, obtained in 1896 from Sebastopol, Sonoma County, through the courtesy of Mr. Fred W. Gill of that town. This fine yellow apple has not been listed yet in any catalogue. The young tree bore eighteen large apples, which were gathered October 5th and kept until the end of December. This variety, therefore, bids fair to give the district east of the Salinas a better keeper than has been known before, as even the Yellow Newtown Pippin is fully ripe by November 1st on these soils east of the Salinas. The quality of Gold Ridge Winter is very fair, and if grown nearer the coast the apple would rank high. It is as good as any apple grown on the substation, and better here than either White Winter Pearmain or Yellow Newtown Pippin.

Among the other new apples, Ivanhoe proved of medium size, a smooth, red-streaked variety that kept only until the middle of October. Eureka, Swaar, and Seek-No-Farther all ripened before November. Terry kept better, but is a small apple. Bethlemite and Duffy's Seedling are not suited to the climate.

In the old orchard in or near the swale, a few apple trees planted in 1899 are now bearing well. Peck's Pleasant, Red-Cheeked Pippin, Early Ripe, Duke of Devonshire, Maiden Blush, Baldwin, Stark, Calvert, Haas, Acme, Shackelford, Huntsman, Lankford, and Montreal Beauty Crab, all bore crops of from 35 to 90 pounds per tree in 1901. Some twenty varieties bore smaller crops of poorer fruit, and need not be listed here. The trees are healthy, and excepting in years of extremely severe and late frosts bear well. The fruit ripens very early, as noted in previous reports, and is not of high quality; but for family use, some varieties of apples are undoubtedly worth planting in selected localities east of the Salinas.

In most cases all these apples began to fall from the trees by October 1st, and had to be gathered. Some varieties in other districts, known as autumn and early winter sorts, ripen by the middle of September. Of the varieties in the older part of the orchard, the best in 1901 were Peck's Pleasant, Marshall's Seedling, Acme, Lankford, and Montreal Beauty.

Pears.—In the young orchard, a few blossoms formed on Lincoln Coreless and several other varieties, and a few pears ripened, but not enough to test any sort. On the older trees on the swale and north on the brown adobe the best crops were on Conseiller de la Cour, the fruit of which kept until late in January; Beurré Gris d'Hiver, which also was a January pear; Nouveau Poitou, which ripened late in December; Doyenne du Comice, which was in its prime at Christmas; Bartlett, which was at its best in September; and Winter Nelis, here a December pear. Some of the Bartlett trees bore 150 pounds apiece. The quality of all the pears was of highest grade. The pears grown here would rank as unusually good in flavor and color in any market. In years of average rainfall, they are of large size.

Plums and Prunes.—The trees yielding best, all on swale soil or northward on brown adobe, were, in 1901, Robe de Sergent Prune, Red Egg, Barry, Petite Prune, Datte de Hongrie, Burbank, St. Catherine, and Bulgarian, also the Myrobalan; but none of these, except the last, bore more than 25 pounds to the tree. Most of these plums bore early for the variety, and none of them except the Myrobalans are holding their own. The only plums for this district are Americanas, and hardy, half-wild types, from which a good deal can be expected.

Other Fruits.—Quinces are beginning to bear in the young orchard, and there is no reason why they should not succeed in this district on good soil. Almonds, apricots, peaches, and nectarines did nothing in 1901. The district east of the river is generally unsuited to almonds and apricots; peaches and nectarines, with care and in chosen spots, do quite well in ordinary seasons. The only mulberry of value for home use here is the Persian, which is both hardy and of very good quality. It should be planted by every land-owner in this region.

Growth of Trees on Hardpan.—A summary of the condition of fruit trees on hardpan for three years before most of the orchard was removed,

or in 1898, 1899, and 1900, shows the following facts: The average annual growth of the cherry tree was 4½ inches; of the almonds, 5 inches; of the peaches, 8 inches; of the plums, 9 inches; of the apricots, 10 inches; of the pears, 18 to 20 inches. Some trees hardly added two inches a year to the length of their branches. There were almost no suckers or fresh side growths to renew the heads.

In every case when trees were removed, the depth to hardpan was recorded. The cherries taken out since 1898 had from 20 to 27 inches of soil above the hardpan. The almonds had from 21 to 25 inches. The apples had from 18 to 24 inches. The plums and prunes had from 16 to 30 inches. Some of the trees taken out at the final clearing in 1901–2, left longest because making the best appearance, stood on a little deeper soil—not over three feet.

THE VINEYARD.

The following table shows growth and yield per vine of leading varieties of grapes on light soil underlaid by hardpan. If planted on stronger and deeper soil, of which there is much in the district, and more especially if planted well up on the hillsides, the growth and yield of a vineyard would undoubtedly be much more satisfactory. In many seasons the late frosts destroy, or at least shorten, the crop of this hardpan vineyard. The crop is usually shortened by the ravages of birds, which attack all kinds of fruit. The vines whose crop was weighed were those which had been least severely attacked:

GRAPES IN 1901.

Variety.	Average Season's Growth of Canes.	Yield per Vine.
Verdelho	2 feet.	2 lbs.
Meunier	3 "	2 "
Cinsaut	3½ "	4 "
Gros Mansenc	3 "	2 "
Carignane	4 "	5 "
Bastardo	3½ "	3 "
Blue Portuguese	2½ "	2 "
Tinta Amarella	4½ "	6 "
Black Morocco	4 "	8 "
Pinot St. George	3½ "	6 "
Golden Chasselas	4½ "	7 "
Folle Blanche	3½ "	5 "
Serine	3½ "	6 "
Crabb's Black Burgundy	4½ "	8 "
Sultana	3 "	2 "
Verdal	4 "	5 "
Tinta de Madeira	4½ "	6 "
Herbemont	3½ "	4 "
Malbec	4 "	8 "
Chauché Noir	3 "	1 "
Pizzutello	6 "	8 "
Muscatello Fino	4 "	5 "
Robin Noir	3½ "	7 "
Burger	4 "	5 "
Petit Bouschet	3½ "	6 "
Mataro	2½ "	6 "
Huasco	2 "	4 "
Charbono	2½ "	1 "
California Black Malvoisie	4½ "	8 "

Out of sixty-six varieties, reported upon by the foreman in 1901, none yielded more than 8 pounds to the vine. The strongest grower by far was Pizzutello, here one of the best table grapes and one of the best bearers of the whole collection. Hundreds of cuttings of this grape, as well as of Black Morocco and others that promised well here, have been distributed in the region.

PERENNIAL GRASSES.

Roots of many perennial grasses were sent to the substation in 1899, to test their drought-resistance. They were planted in plots, irrigated once or twice to give the roots a foothold, and were afterward cultivated. Nearly all failed to endure the summer. *Andropogon citratus* (lemon-grass) died down, but sprouted again with the first rains, and by December 1st was from 8 to 12 inches high. This is a valuable early winter grass for the region. Another which grows in much the same way here is *Panicum altissimum* (tall panic). *Paspalum compressum* also started with the first rains, but made very little growth.

The late frosts, April 10, 1900, injured *Paspalum dilatatum* (large water-grass), also the rye-grasses, also *Phleum pratense* (timothy), *Panicum bulbosum*, and *Agrostis vulgaris* (red top). It was too dry for any of these. Bermuda-grass was also frosted, but recovered and started again, keeping green until autumnal showers, when it grew quite well.

Panicum molle (para-grass) kept green until the early rains, but only grew slowly in winter. *Sporobolus wrightii* made a growth of 4 to 5 feet, and bloomed. Cut back, it grew again the following season.

Bouteloua curtipendula (the side-oats grama of Nebraska) made a fair growth and kept green all summer. It grew poorly in winter and died the next season. *B. juncifolia* is the only one of four species of grama-grass which has stood three seasons.

Eragrostis tenuis (branching spear-grass) kept green all summer, and so did *Elymus arenarius* (sea lyme-grass), *Elymus triticoides*, a Pacific Coast species, *E. canadensis glaucifolius*, *Agropyrum pseudorepens* and *A. spicatum*, also *Lygeum sparteum*. One of the best of all the grasses grown was the many-flowered millet (*Oryzopis miliacea*), which remained green all summer and made a large winter and spring growth.

Seventy-two species were grown in all, thirty-two of which died before the end of the first season, and fifteen proved too tender.

WHEAT EXPERIMENTS.

In addition to the experiments elsewhere described with gluten wheats, etc., four plots were sown in 1900–1901 to White Australian wheat, three of which were variously fertilized for hay crop. All were sown December 10th, and cut May 31st. The results were as follows:

	Thomas Phosphate per Acre.	Sodium Nitrate per Acre.	Yield of Hay per Acre.
Plot 1	500 lbs.	180 lbs.	6,225 lbs.
Plot 2	500 "	----	4,395 "
Plot 3	----	180 "	7,087 "
Plot 4	----	----	2,669 "

The considerable difference between plots 1 and 3, which is more than ten per cent, is doubtless due to differences of soil, though in appearance the plots were the same.

In 1899 there were field tests made of fifty varieties of wheats, including thirteen Algerian varieties and a number of cross-bred sorts from Australia. Sown January 9th, and heading out after May 10th, the ripe wheat was cut from July 11th to July 28th. The stalks ranged in height from 22 to 37 inches; and the heads varied in length from 2½ to 4½ inches.

The crop, in drilled plots, ranged from a rate of 907 to 5,142 pounds per acre. All the Algerian wheats, such as Hamra, Adjini, and Chetta, yielded above the average, and ripened among the earliest. King's Jubilee Improved Fife yielded at the rate of 4,235 pounds per acre, and was very early. Ratling Jan × Hornblend and Indian was nearly as early as any, and gave a yield of 4,537 pounds per acre. Steinwedel × Quartz and King's Jubilee and Steinwedel and Amethyst × Hornblend and Early Baart, also Cujanian, Clawson, and Chili, were among the best. No. 30 American Select yielded more than any other variety, or at the rate of 5,142 pounds per acre, and ripened July 14th. Pride of Genesee, Turkish Red, and Currell's Winter did not ripen until the end of July, and did very poorly for drilled plots, being less than one fourth the crops of the better varieties named.

This experiment showed early the great difference in varieties grown here, and the value of some of the new cross-bred wheats. Reviewing the work of the substation since its establishment, on cereals, it may be said, briefly, that a very large number of varieties of wheat, barley, rye, spelt, and millet have been grown here, on both the granite hardpan and the deep adobe soils. The region in years of average rainfall is exceedingly well adapted to cereal crops. The substation has steadily practiced early planting on well-prepared ground, drilling, and breaking of the crust when needed. The resultant crops on small plots have been exhibited at County and State fairs on numerous occasions. Seed of the best varieties has been locally distributed. There is an increasing demand for a continuance of experiments with cross-bred wheats, barleys, and other cereals, in order to secure greater drought-resistance and better yield, and this is one of the most hopeful lines for future work.

Wheat Hay Experiments.—The question being locally asked of the substation, whether "it made much difference what kind of wheat was sown for hay," a series of plots were laid out in 1898–9—some on the swale soil, which was too wet to be sown until January, and some on the lighter soil. The results were surprising to the district. In every case, the plots were broadcasted. The following table shows results. No fertilizers were used, and the soil was uniform, having shown in previous years, when sown to one variety, no appreciable difference between plots. As the late rains were abundant, the plots on the light soil came out very well, although sown so late. In the case of the hardpan soil, it is in wet years impossible to plow early, as horses can not walk on the surface.

Variety.	Soil.	Sown.	Cut.	Yield per Acre.
Hornblend × Indian G.	swale	Jan. 4	May 22	2,820 lbs.; few leaves.
Hornblend × Early Baart R.215	"	" 4	" 22	2,980 lbs.; few leaves.
Marjorica Carusa × Blount's Fife and Ward's Prolific	"	" 4	" 25	3,610 lbs.; excellent hay.
Marshall 8 × Gypsum and Ward's White	"	" 4	" 25	4,800 lbs.; excellent hay.
White Sumatra × Ward's Prolific	granitic sand	" 21	" 23	2,774 lbs ; excellent hay.
Sonora	" "	" 21	" 22	3,000 lbs.; fair hay.
Steinwedel × King's Jubilee and Indian A	" "	" 21	" 25	3,030 lbs.; fair hay.
Jacinth × King's Jubilee and Leak's	" "	" 21	" 25	3,105 lbs.; excellent hay.
Ward's Prolific	" "	" 16	" 25	5,150 lbs.; excellent hay.
Frame's New × Australian	" "	" 16	" 25	6,570 lbs.; best of all in quality.

SEEDS FROM WASHINGTON, AND ELSEWHERE.

A number of introductions, chiefly sent out by the Department of Agriculture, have been tested here, and some of the more promising cultures are being continued.

Ryes.—No. 4343, Abruzzi, from Naples, was sown December 1, 1900, and required fourteen days for germination. It came up evenly, and made a good stand. It headed out by March 20, 1901, and was harvested and threshed in July, yielding a fairly good crop.

No. 5031, Schlousted Winter Rye, sown at the same date, December 1, 1900, also germinated in fourteen days. This variety headed by April 20, 1901, yielding very fairly for the amount of straw.

No. 5058 was sown on the same date, also requiring fourteen days for germination. This kind headed by May 10th, yielding fairly.

These three ryes were distributed by the Central station in 1901.

Wheats.—No. 3823 (original seed of Gluten Wheat) was sown December 10, 1900, and required from twenty-eight to thirty days for germination. This germinated poorly and grew very slowly, but headed by May 22, 1901. It was harvested early in July and seed saved, some of which was sent to Washington, and some to Berkeley. Another plot was sown in the fall of 1901 from this seed, which was somewhat shriveled and small.

No. 3823*a* (the first-remove California-grown wheat) was sown December 10, 1900, requiring sixteen days for germination. It started well, made a good growth, headed by May 19, 1901, was harvested early in July, and threshed. The grain was more plump and larger, and contained more starch than the original seed.

No. 5486, "Dawson Golden Chaff," sown December 10, 1900, required sixteen days for germination. This germinated well and grew well, although slowly at first. It headed by May 14, 1901, and was harvested early in July. The grain was plump and full and yielded a heavy crop.

No. 5493, "Fultz," was sown December 10, 1900, and germinated in sixteen days. It headed by May 14, 1901, and was harvested early in July.

No. 5486 was sown December 10, 1900; it germinated well and made good growth. It headed by May 14th, and was harvested early in July. This grain was plump and full, heads being well filled.

No. 5145 (from Missouri Experiment Station) was sown December 29, 1900, and germinated very slowly and poorly. The land was very wet and much of the seed rotted in the ground. What grew headed by May 25, 1901, and was harvested early in July. The heads were well filled and grain was plump and full.

Barley.—No. 5590 was sown December 20, 1900, and germinated in twenty days. It made a thick, heavy growth, headed by May 1st, and ripened by June 5th. This was cut and threshed by July.

No. 5592 was sown December 25, 1900, and germinated in twenty days. It made a heavy growth, headed April 26, 1901, and was ripe by June 1st.

No. 5793 (Moravian or Hanna) was received late, so was not sown until February 27, 1901, but germinated in seven days, making a good stand. It headed by May 25th and was ripe June 15th. This gave a very heavy crop.

Vetches.—All the vetches noted in the chapter on the Sierra Foothill Station have been tested here for several seasons. *Vicia narbonensis* (No. 1509), sown November 24th, bloomed March 20th, and made fair early growth, but dried up by June 1st and did not mature seeds. No. 1507 was not injured by the spring frosts, but made small growth. The one best adapted to the region is the Hairy Vetch, which has been grown alone and mixed with rye or oats. Sown in November or December, it germinates in from fifteen to eighteen days and can be cut for hay the first week in June. Hairy Vetch sown November 8th with Russian rye (No. 1342) did very poorly; sown with oats (No. 1178) the same date, it made an excellent stand.

Egyptian Clover.—Nos. 4254 and 4256 were sown December 21, 1900, and required twenty-one days for germination, which was good in both varieties. Both made good growth for a time and stood three inches high, when both were badly injured by April frosts and the foliage killed. The stems survived and began to put forth new growth, but finally died without making any growth to speak of.

The district is as a rule too cold for this plant. In 1899, however, it was the best clover grown at the substation; but in 1899 many clovers grew very well.

Cañaigre.—The cañaigre now growing on the substation is from seed sown in the spring of 1899 and planted out in rows January 3, 1901, when the roots averaged six to the pound. The tops died down during the summer, but new growth came up after the rains set in and was from eight to ten inches high by the end of February. Cañaigre does well here.

Dwarf Essex Rape.—Seed of this well-known forage plant was sown November 26, 1900, and germinated in nineteen days. By April 1, 1901, it averaged eighteen inches in height. A portion was then cut, and yielded at the rate of over 9½ tons per acre. By May 7th it averaged over two feet in height. A portion was then cut, and yielded at the rate of over 15 tons per acre. At this time many of the plants were in bloom, and the stalks were woody. Cows rejected the ends of the stalks, but sheep ate stalk and all. The portions cut April 1st and later, made new growth of over one foot high by June 1st. This new growth continued green all summer, and cows, horses, and sheep kept feeding on it, and when the ground was broken up for hay in December, the roots were still green and throwing up new growths. This rape promises to become a very profitable plant to cultivate in this district.

March Rape.—No. 1449, from the Department, was sown November 10, 1899, and germinated in ten days. It began to bloom March 4, 1900, when only six to eight inches high. The Dwarf Essex Rape is much better adapted to this locality. Sown the same year, on October 25th, the Essex Rape germinated in six days and stood eighteen or twenty inches high by March 1, 1900. When cut for hay during April it yielded 13 tons of green fodder per acre. As noted in the preceding paragraph, Essex Rape did even better than this the following season, 1900–1901. At Amador substation, however, March Rape far surpassed the Essex.

Turkestan Alfalfa.—Nos. 1150 and 1151 were sown November 11, 1899, each taking nine days to germinate. Both made short growths, averaging about six inches, and were pretty well dried-out by May 25th, but the roots survived and started again the following winter.

Bromus inermis (No. 3004).—This grass, sown November 8, 1899, requiring twelve days for germination, made a short growth and was dried up by June 1, 1900. In some years this grass remains green until August. It is worthy of extended planting.

Russian Millet.—No. 1387 was sown March 21, 1900, and required fifteen days for germination. It was irrigated several times, headed by June 5, 1900, and ripened by July 26th. The yield was very poor.

Broad Beans.—No. 1454 was sown November 11, 1899, germinated November 26th, and bloomed March 17th when three feet high. Destroyed by frosts of early April and subsequent hot weather. All beans of this class have failed here, chiefly by reason of late spring frost.

Lentils.—Nos. 1466 and 1483 were sown at various times, as also a collection from Vilmorin, and the noted Big Hiller Lentil of the Volga region. Sown late in November, they bloom about the end of April and make a good early growth, covering the ground. The heat of summer dries them up, and they seldom mature seed.

Goat's Rue.—No. 1456, sown November 27, 1900, made very poor growth. Some remained green until the following August. Goat's Rue will not stand the summers here.

Safflower.—No. 1343, sown December 4th, grew three feet high, bloomed May 30th, and kept green until autumn.

Foxtail Furze.—No. 1446, sown November 11th, germinated December 12th, and grew ten inches high the first season. It stood the dry weather very well, and seems worthy of extended trial.

Alfalfa from the Estrella.—Seeds of a selected alfalfa from Mr. J. Marden, of the Estrella, said to be quite resistant, sown November 15, 1899, has stood the dry weather better than did the Turkestan. All the varieties of alfalfa tested here required some water in summer to carry them through.

Iris pabularia.—Widely advertised as a dry-land forage plant. Its leaves die down to the ground here by the middle of July, but the roots remain alive.

Lathyrus sylvestris (No. 1460).—This pea has been grown here for a number of seasons. It must be sown early. It makes poor growth, but remains green without irrigation until the end of July.

Rye-Grasses, Clovers, etc.—A collection of rye-grasses from Sutton & Co. was sown here November 24, 1899. All need irrigation to keep alive. The same is true of white clover, red clover, yellow trefoil, *Triticum scabrum* of New Zealand, *Cynosurus cristatus*, and a great number of well-known forage plants. Schrader's Brome-grass (*B. unioloides*) will grow two feet high in ordinary years, ripening seed in June, but dried up by June 30th. *Elymus glaucus* (wild rye) makes a good stand and

will in some seasons stay green until July. *E. canadensis* and other species tested here were about the same as *E. glaucus* in drought-resistance, excepting *E. condensatus* (giant rye-grass), which kept green in 1899 until autumn without irrigation, far surpassing in this respect *Bromus inermis*.

Jersey Kale.—This plant, after many years' trial here, is found to stand the dry climate reasonably well, and it keeps green all summer without irrigation. Livestock eat it readily and it is much used in the vicinity as green feed for poultry.

Saltbushes.—*Rhagodia nutans* and *R. spinescens inermis* grow moderately well here, but the latter is much better than the former. *Atriplex cachiyuyum*, *A. pamparum*, and *A. nummularia* are all doing well on the substation. These make very heavy growth and stand the dry climate superbly. When measured May 7, 1901, plants set out from seed boxes May 23, 1900, were in size as follows:

	Best Plant.		Average.	
	Height.	Spread.	Height.	Spread.
Atriplex nummularia	26 in.	20 in.	20 in.	15 in.
Atriplex pamparum	18 "	36 "	14 "	30 "
Atriplex cachiyuyum	16 "	36 "	12 "	30 "
Rhagodia spinescens inermis	27 "	30 "	18 "	18 "
Rhagodia nutans	10 "	20 "	6 "	14 "

These saltbushes were cultivated but not irrigated since transplanting. They have not suffered from frost, although the temperature fell to 17° Fahr. three nights in succession in January, 1901.

VEGETABLES.

The climatic conditions are well shown by the foreman's notes on a small vegetable garden in 1899 and 1900.

Radishes (scarlet turnip) sown February 13th were ready for use March 25th. Sown October 2d, were fit to pull October 25th. White Chinese and Osaka radishes sown October 2d were ready for use November 10th, and so continued until March 10th. Radishes sown in March were valueless.

Lettuce in large variety sown February 13th, made excellent heads by May 1st and were used until June 10th. Volunteer lettuces starting with the October rains were fit to use by Christmas.

Onion sets planted February 14th were used March 25th. Onion seed planted the same day grew, but the plants failed.

Carrots, turnips, table beets, and garden peas, sown February 14th and March 28th, also failed to mature. Rostow sugar peas sown January 28th, however, made a start and peas were fit for use May 10th. Rutabagas in variety did better than the white turnips. Carrots sown October 2d were ready for use January 20th.

Spinach (Victoria), also sown October 2d, was fit to cut February 10th, and "yielded four crops."

Garden beets sown in October failed to mature.

Purple-top turnips sown October 17th were of marketable size February 10th.

As these brief notes show, early planting is needful in this district. It is the universal experience of farmers here that by planting gardens with the first rains, they can have a great variety of choice vegetables in the spring months.

MELONS AND SQUASHES.

The watermelons grown in this region are generally of excellent quality, but muskmelons do not do as well; the vines, as well as those of squashes, suffer from sunburn. The following notes are mainly from those taken by the foreman, Mr. Barber, on various melons, etc., grown in 1900. All were on good soil, none on "hardpan."

Kleckley Sweet (Watermelon).—Seed planted March 31st, germinated twenty per cent April 20th. The first melon was ripe August 28th. Long, narrow oval in shape, dark green, with thin rind. Flesh red, tender, crisp, juicy, sweet. Fine quality and flavor. Seeds white. Weight up to fifteen pounds. Did not bear well.

Fordhook Early.—Planted March 31st, germinated eighty per cent April 19th. First melon ripened August 5th. A broad, irregular oval melon, jade-green and mottled; rind thin. The early melons were of poor quality, juicy but not sweet, with a hard core. The later ones were much better, tender, juicy, and sweet, with red flesh and good flavor. Seeds white. Weight up to eighteen pounds. Bore well.

Hungarian Honey.—Planted March 31st; germinated sixty per cent on May 4th, a very slow germination—seed probably old. The first melon ripened August 20th. It was very small, round, dull green, and mottled. The rind was thin; flesh tender, juicy, and very sweet. Flavor excellent. Seeds brown. Vines poor bearers and fruit too small for market. In some seasons and places the melons of this small, round type are among the most popular for local consumption in the Coast Range towns, weighing from five to ten pounds. At the substation this melon has never been large, but it was one of the best a few years ago in the Willow Creek district.

No. 4269 of the Department of Agriculture.—The melon received under this number from Washington came originally from Monetta, South Carolina; was also named the "Mathis." It belongs to the Kolb Gem type, and was said to be a fine shipper. Sown April 12th, only one seed germinated, May 4th, and was destroyed by squirrels.

No. 1194 from the Department of Agriculture.—This interesting watermelon from Sarmakand, Russian Turkestan, was sown March 31st. One hill grew, May 4th, and the first melon ripened August 5th. The fruit was globular, pale green, with slightly darker stripes; rind thin; flesh pink, very tender, crisp, juicy, sweet, and "melting like sherbet." Quality in all respects very fine. The melon was very small, however. The seeds were black and small.

Other watermelons received from the Department of Agriculture were No. 1070, a variety from Kief, known as the "Monastery"; No. 1089, from Odessa; and No. 1220, from Tashkent in Turkestan. The first of these three was an excellent, small striped melon, but rather late. The others did not germinate. The largest of all the melons received from Asia was No. 727, from Udjarri, between Tiflis and Baku, Transcaucasia; a large, green-striped fruit weighing up to eighteen pounds. The flesh was pink, with a tinge of yellow, and seeds were black. It had no advantages over the best American varieties.

Kolb Gem, a well-known sort, sown March 31st, germinated seventy per cent April 30th, and melons ripened June 25th, thus beating Fordhook First by eleven days. The fruit was of excellent quality. The weight varied, up to twenty pounds.

Honcharenko.—This was a small but very fine melon obtained from Agapius Honcharenko, near Haywards, in Alameda County, and was distributed in the winter of 1900. Sown March 31st, seed germinated sixty per cent April 19th, and the melons were ripe July 29th, beating Fordhook First seven days. This was a round melon of pale green color with slightly darker stripes. The rind was very thin indeed; flesh was light red, crisp, tender, juicy, sweet, best flavor. A good bearer. The weight rose to fifteen pounds in a few cases, though many ran from five to ten pounds. This was one of the best melons ever grown at the substation.

The Small-Seeded Melons.—There is much resemblance between the three small, round melons, Hungarian Honey, Honcharenko, and No. 1194 from Sarmakand, and the last-named, the smallest of the three, may well be the original type from which the others came, one by way of the "central route" into northwestern Europe, the other by the way of Asia Minor to Mount Lebanon, whence Father Honcharenko, a priest of the Eastern Church, obtained it. All three melons are highly drought-enduring, the small, narrow leaves curling up edgewise more completely than do the leaves of the larger sorts, and all three are usually prolific.

Pumpkins and Squashes.—The Red Etampes and the Mammoth Tours pumpkins and the Cashaw squash, planted April 3d, germinated April 19th and grew well for a time, but were attacked by "wilt disease," and only the Cashaw squash survived, making a poor growth and yielding only a few squashes.

THE SAN JOAQUIN VALLEY SUBSTATION.

(One mile southeast of Tulare City, Tulare County. Elevation of site above sea-level, 282 feet.)

This substation, perhaps more nearly than any other, is the direct outgrowth of a long-continued study of one of the greatest of agricultural problems. "Alkali lands," which are rendered more or less unfit for use by reason of an excess of salts of various sorts, exist over large areas and in many parts of the world. In the San Joaquin Valley and other portions of California the presence of surplus alkali constitutes the chief difficulty of the land-owners, and efforts to conquer it date back to the beginning of agriculture in these regions.

Alkali soils were discussed in the biennial report of the College of Agriculture for 1875–6, page 43, and again much more in detail in the following biennial, 1877–8, pages 30–39. As the great importance of the subject has become manifest in succeeding years, more and more attention has been given to it by the California station, so that the bulletins and portions of reports on the subject issued in the past twenty-five years would form, if collected, a large volume.

The Tulare substation, established in 1888, has since that date tested an enormous number of different species of plants on various grades of alkali. The results are scattered throughout recent publications, and form the most complete series of such experiments which have been made in the United States. Over and over again seeds are received as "new in the San Joaquin Valley," or "worth trial there," which were long ago given a thorough test and found worthless. None of the cowpeas (*Vigna catjang*), for instance, are of any avail here, and none of the vetches can be said to succeed on alkali soils; but questions are still asked every year about both cowpeas and vetches, which thrive in the Sierra foothills, twenty miles distant.

The progress of actual work in alkali reclamation and the history by charts of the rise of alkali here, were given in Part II of the report for 1898–1901. The present season of 1902 is in some respects the hardest one for agricultural work since 1888, and results can be shown only on irrigated areas; and not always there, owing to the way in which the heavier alkali soils run together when wet, preventing germination of seeds.

Changes and Improvements.—There has been little money spent on this substation since the issuance of the report of 1897–8. A new well was sunk and a pump and horsepower installed. In order to make irrigation effective, five or six acres should be graded, and a pipe, or wooden boxes, used to carry and measure the water accurately. No changes have occurred in the local officers; Mr. Julius Forrer remains foreman, and Mr. John Tuohy, Patron.

Local Value of the Station.—In 1900 and 1901 the substation made extensive exhibits at the agricultural fairs of Tulare and Kings coun-

ties, and distributed bulletins, seeds of saltbushes, etc. The distribution of cuttings of figs, grapes, mulberries, etc., has been extensive for the past ten or more years. A small price is now put on grape cuttings to aid the "sale fund," and the demand increases each year. Local correspondence and number of visitors are greater than formerly.

CLIMATE.

The climate of the region, while healthful, places decided limitations upon plant growth. With water, and wherever the amount of alkali is on the safe side, very large staple crops are grown, and some fruits are extremely successful. There are such large areas where these conditions prevail that the prosperity of the upper San Joaquin as a whole is permanent, but still the areas where plant life suffers are of considerable extent, and in such places irrigation, drainage, and alkali-reclamation are essential.

Rainfall.—The average rainfall for the past twelve years at this point has been 8.37 inches. The average at Tulare City is less than at Visalia, Porterville, or Hanford, all points in the valley within twenty miles distance. Visalia and Porterville are nearer the Sierra, and Hanford, farther west and north, is nearer the ocean and the Coast Range. The following table gives the rainfall in inches at the substation for ten years past and, with the comments which accompany it, illustrates the differences of successive seasons:

RAINFALL (INCHES) BY MONTHS FOR TWELVE SEASONS.

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	Total.
1892–3	.00	.26	.39	1.51	.64	1.20	3.02	.33	.00	7.35
1893–4	.00	.00	.05	1.07	1.24	.38	.77	.09	.26	3.86
1894–5	.00	.18	.02	2.44	3.25	1.23	.86	.60	.60	9.18
1895–6	.00	.43	.98	.36	1.78	.01	.72	.14	.14	4.56
1896–7	.00	.74	1.11	.59	2.43	1.61	1.73	.00	.00	8.21
1897–8	.59	.59	.26	.79	.63	.97	.72	.00	.59	5.14
1898–9	3.75	.01	.16	.19	.92	.14	2.28	.17	.02	7.64
1899–1900	.00	1.35	1.32	1.28	1.02	.10	.77	1.73	2.03	9.60
1900–1901	2.18	.04	2.41	.19	3.27	1.19	.36	1.11	1.87	12.62
1901–1902	.42	.39	.36	.03	.40	2.28	2.14	.74	----	6.76

Such a table as this is difficult to explain to persons unused to the San Joaquin region, but the amount of rainfall is not nearly as deficient as might appear. From 7 to 8 inches—the average of the past thirty years here—is sufficient to produce a crop of cereals, provided that this small amount of rainfall is properly distributed. The amount of winter irrigation needed, therefore, is not great.

It is true, however, that an unfavorable distribution of the rainfall often occurs. In 1898–9 the rainfall of 7.64 inches gave very poor crops, almost a failure, in fact; but in 1892–3 a less rainfall (7.35 inches), well distributed, gave fair and profitable crops throughout this district. Even the large rainfall of 1900–01 (12.62 inches) was so badly distributed (the two inches which fell in September being of little or no value, and the dry March being very bad for grain) that the season as a whole was but an average. The present season (1901–2) entirely lacked early rains sufficient to start plows. Two or three inches of rain in November or December with the February and March rains received would have made large crops. Much of the rainfall of 1899–1900 was of little avail

for farmers, and better distribution of the April and May rains would have doubled the crops. The rains of 1894–5 came so as to yield large returns, and those of 1896–7 were also well distributed.

The application of from 6 to 12 inches of irrigation water (from a half acre-foot to one acre-foot) will evidently be sufficient to secure regular cereal and other crops in such a country as this.

Temperature.—The temperature reports from this and other substations appear in the United States Weather Bureau reports, and the leading features of this climate are now well understood. The following table shows the monthly summaries since and including January, 1898:

MONTHLY SUMMARY OF TEMPERATURE.

Month.	Maximum.	Minimum.	Mean Max.	Mean Min.	Mean Tem.
1898—January	70°	20°	58.90°	28.90°	43.90°
February	84	32	72.50	39.71	56.10
March	92	24	74.19	35.54	54.87
April	106	32	87.76	54.70	66.73
May	104	42	85.03	48.96	67.00
June	110	48	98.86	57.40	78.13
July	112	54	104.96	61.87	83.41
August	112	50	103.93	60.85	82.25
September	112	48	91.80	53.46	72.63
October	88	40	82.19	48.71	65.65
November	80	24	69.93	34.26	52.10
December	72	18	60.06	30.19	45.12
1899—January	78	26	63.00	36.00	49.38
February	84	18	70.28	31.85	51.07
March	94	26	69.87	40.15	55.16
April	102	36	80.93	44.66	62.80
May	100	34	82.06	46.06	64.06
June	112	50	96.66	59.40	78.03
July	114	54	106.45	59.55	83.00
August	104	48	95.87	55.35	75.61
September	108	46	98.20	53.06	75.63
October	96	38	75.87	44.90	60.38
November	82	34	68.06	43.60	55.83
December	70	28	57.93	38.25	45.09
1900—January	70	30	53.22	41.09	47.16
February	82	30	66.28	36.92	51.60
March	94	30	76.19	42.83	59.51
April	92	34	72.60	43.46	58.03
May	100	42	86.06	52.19	69.12
June	108	50	98.40	59.00	78.70
July	112	92	103.48	61.16	82.32
August	110	50	96.45	56.51	76.48
September	100	42	87.40	49.93	68.66
October	96	30	79.54	45.87	62.70
November	88	36	70.80	44.46	57.63
December	64	26	53.74	37.35	45.54
1901—January	74	22	58.25	37.67	47.90
February	76	30	63.22	41.14	52.28
March	84	28	70.58	39.74	55.16
April	86	30	76.20	39.33	57.76
May	96	42	82.12	51.09	66.61
June	112	46	99.93	54.80	74.36
July	112	50	103.61	60.31	81.96
August	110	50	99.87	62.25	81.06
September	102	44	88.86	50.06	69.46
October	100	38	85.29	49.35	67.32
November	86	32	77.06	40.20	58.63
December	78	18	69.22	30.32	49.77
1902—January	78	20	56.58	32.00	44.29
February	92	24	69.14	39.78	54.46
March	90	32	68.00	39.54	53.77
April	88	38	75.46	43.66	59.56
May	---	--	------	------	------
June	---	--	------	------	------

The highest temperature ever recorded at Tulare was 120° Fahr.; the highest recorded at the substation since 1888 was 119° (in July, 1892, and June and August, 1895). Since 1895 the thermometer has not recorded over 114° (July, 1899), but has often reached 112°. It is a dry heat, healthful, excellent for outdoor labor, and where the water supply has been sufficient, is excellent for many kinds of crops. Where surplus alkali does not interfere, the climate produces unsurpassed peaches, raisin grapes, alfalfa, etc.

FROSTS AND FROST EFFECTS.

Severe frosts are common, and in this part of the valley seriously limit the culture of some otherwise profitable crops, such as figs, olives, and oranges. All these belong to the region nearer the foothills. The lowest temperature recorded at the substation was 17° Fahr., but points in the district have a minimum record of 14°, and 20° to 22° quite often occurs. At the substation in eight successive winters, November averaged 4 frosts a year; December, 9; January, 7; February, 3; March, 3, and April, 1.

Since the last report, the number of frosts recorded was as follows:

NUMBER OF KILLING FROSTS.

	1900.	1901.	1902.	Lowest Temp.
January	1	7	17	20°
February	3	4	2	18
March	1	1	0	28
April	0	2	0	32
November	0	0	0	--
December	3	22	0	18

The number (22) of frosts in December, 1901, beats the record here, and that of January of the present year is also unusual. Such long-continued cold is very severe on plant growth, as the following notes will show:

The Carob.—Many trees which have stood fairly well here for many years past have now been greatly injured or killed outright by frosts. The last two of the carobs (*Ceratonia siliqua*), with trunks of 3 or 4 inches in diameter, were killed to the ground, but are sending up masses of sprouts from the crown. The tree is utterly unfit for this district.

Grevillea robusta.—This fine tree, which had reached a height of 25 feet and a trunk diameter of 7 or 8 inches, was badly affected, large branches being killed. Trees in the town of Tulare, in Visalia, and in Hanford also suffered. The Grevillea, or Australian fern tree, is unfit for planting in the valley.

Oranges.—Both sour and sweet stock oranges were nearly destroyed. Another such winter would compel the removal of the stumps. Young growth now starting freely requires several seasons to mature sufficiently to be again reasonably safe. Orange trees suffered in the surrounding country nearly to the foothills; Lindsay, Porterville, etc., escaped quite well. A small Kumquat, or gooseberry orange from Japan, proved hardier than the others. It was somewhat sheltered by a fig tree, but still was evidently more frost-resistant than the standards.

Camphor (*Cinnamomum camphora*).—This beautiful and valuable tree, which withstands some alkali and has hitherto grown well in the region, suffered severely. The lower 12 or 15 feet of leaves and side branches were pretty well destroyed, but new buds have now started. Cold of 18°, and 39 successive frosts in two months, December and January, were all that this tree could stand—marking the extreme limit of its endurance. The top of the tree was untouched and it will recover rapidly.

Olives.—The olive trees have nearly all suffered. The crop was of course destroyed in all cases where it remained on the trees after December 1st. The following varieties were very badly injured, the trees being practically frozen to the ground, or at least to the main stem.

Nevadillo blanco	Killed to the ground in heavy alkali soil; half killed in sandy soil.
Corregiolo	Only injured in heavy alkali.
Razzo	Badly affected everywhere.
Atrorubens	Worst in the alkali soil.
Columbella	Partially frozen on alkali soil.
Nigerina	Injured only in heavy soil.
Rubra	Injured in heavy soil; not touched on the sand.
Uvaria	Partially frozen.

The most tender of all these trees is Nevadillo blanco, which has no value here. The following varieties of olives stood the frost considerably better than the preceding list:

Amellau	Lavagnino	Mission	Piangente	Regalis.
Atroviolacea	Macrocarpa	Oblonga	Picholine (true)	Salonica
Bella de Spagna	Manzanillo	Palazzriolo	Pleureur	Tagiasco
Frantoio	Morchaio	Pendulina	Polymorpha	

Præcox has hitherto been very hardy; this year it suffered considerably. Atroviolacea also suffered some that year. On the sandy soil the following varieties were not injured: Rubra, Manzanillo, Salonica, Oblonga, Mission, and Macrocarpa.

The best olives here for hardiness prove to be the following: Macrocarpa, Manzanillo, Mission, Oblonga, Pendulina, Redding Picholine, and Salonica. Where there is little alkali and the soil is light, a few others make good trees and withstand frost fairly well, but the safer list on heavier soil includes only the seven varieties mentioned. The oldest trees near the house suffered more than in previous years, and here the Mission and Columbella were noticeably the best, and were full of bloom by May 1, 1902. Columbella is tender on the heavy alkali soil; on light and less alkaline soil it is one of the best.

African Date Palms.—These have suffered more during the last winter from frost than in any previous year. None were killed, but all, even Seevah, the hardiest, were cut back badly. This variety is the earliest bloomer; it was in flower April 1st, Amhat and other male plants being generally only in sheath then. The impossibility of natural pollination is evident. If this plantation were at Lindsay or Porterville it would grow much better and perhaps the varieties would bloom nearer together, as the more tender sorts are the ones whose growth is severely checked and which blooms late. None of the palms except Seevah bloomed in 1899 or 1900. In 1901 two male varieties bloomed.

Eucalypts.—On the south side of the station tract is a row of large eucalyptus trees. These were planted ten or twelve years ago, and

many species have done very well here. Among these are *E. amygdalina*, *E. corynocalyx*, *E. rostrata*, and *E. viminalis*. The common blue gum (*E. globulus*) has often suffered from frost. This winter (1901–2) many species were severely injured, the young shoots and lesser branches

PLATE 4. EUCALYPTUS VIMINALIS ON STRONG ALKALI.

being killed. The photograph (Plate 4), which shows a large *E. viminalis* in the center, illustrates how well these eucalypts have grown on quite strong alkali soil.

In this district the best species to plant are undoubtedly *E. rostrata*, *E. viminalis*, *E. corynocalyx*, and *E. amygdalina*, all strong growers and

valuable trees, with *E. globulus*, the most rapid grower, worth using only where it does not suffer from frosts. There is at Tulare City a large grove of eucalypts made by the Southern Pacific. Here some fifteen species are represented, and nearly all have done well, the more tender species being sheltered by the taller and hardier trees. *E. eugenioides*, *E. leucoxylon*, *E. robusta*, and *E. obliqua* are in this collection.

THE ORCHARD.

The substation orchard has remained about the same for the past few years, the alkali being controlled by small applications of gypsum, as elsewhere noted. The quality of some of the fruit is better than it was a few years ago, as the trees are now in these cases healthier. Experience has shown that this region is unfitted for certain lines of fruit culture, but there is undoubtedly some reaction toward more planting of suitable sorts and on good land. The substation orchard has now been maintained a long time and is very significant in its results. No other orchard now exists which was set at the same time on similar soil.

Apples.—No more apple trees have yielded to alkali, and the crops since 1896 have been of increasing quality and size. The following table shows the varieties which did best in 1901. Some of the fruit was quite small, but most of it was of fair size and some very large. The "ripening season" is notably at variance with that of the same varieties in other districts:

APPLE STATISTICS AT TULARE SUBSTATION.

Name.	Began to Ripen.	Average Weight.
Alexander	July 19	8½ oz.
Bledsoe	Aug. 22	9 "
Fameuse	Sept. 14	4½ "
Grimes' Golden	Sept. 28	7½ "
Hoover	Sept. 8	8½ "
Jonathan	Sept. 14	5 "
Keswick Codlin	Aug. 8	2½ "
Lincoln	Aug. 1	6 "
Loy	Aug. 2	7½ "
Missouri Pippin	Sept. 8	6 "
Mountain Beauty (crab)	July 12	½ "
Northern Spy	Sept. 28	5 "
Pewaukee	Sept. 28	8 "
Red Bietigheimer	July 19	12 "
Rhode Island Greening	Sept. 15	7 "
Shirley	Sept. 25	6 "
Violet	Aug. 8	12½ "
Whitney Crab	July 12	1½ "
White Astrachan	July 24	12 "
White Winter Pearmain	Sept. 28	10 "

None of the above apples are good keepers here; they do not last long after being gathered, and by November 1st even the winter sorts are practically gone. The quality of the early apples is somewhat better than that of the later sorts, which are apt to be tough and tasteless, fit only for kitchen use. In the years of lowest summer temperature the quality of the apples is better than in the hotter seasons; sometimes many of them are fairly cooked on the trees.

Pears.—The great value of this fruit in this region has before received comment. It is one of the trees best adapted to alkali soils, when not

too strong. But in the past three years much blossom blight has injured crops in the district, and in 1901 there was little fruit anywhere except at the substation, where the little blight that appeared in the spring of 1902 was sprayed with copper solution.

The pears which bear best are Andre Desportes, Beurré Gifford, Beurré Gris, Beurré Clairgeau, Clapp's Favorite, Dearborn Seedling, Kennedy, Howell, Idaho, Lawson, Mt. Vernon, and White Doyenne. Bartlett has hardly had an even chance, standing as it does in stronger alkali. Seckel bears poorly, but the fruit is excellent. Many other sorts bear well some seasons. The following table gives the statistics of an average crop:

STATISTICS OF PEAR ORCHARD.

Variety.	Date When Gathered.	Average Weight.
Andre Desportes	July 14	3½ oz.
Bartlett	Aug. 8	8½ "
Beurré Gifford	July 12	4 "
Beurré Gris	Oct. 23	6½ "
Beurré d'Amanlis	Aug. 2	5 "
Beurré Lucrative	Aug. 2	4½ "
Beurré Clairgeau	Sept. 4	10 "
Beurré d'Anjou	Oct. 2	8 "
Barry	Oct. 17	3 "
Black Pear of Worcester	Oct. 2	10 "
Conseiller de la Cour	Aug. 8	10½ "
Cole	Aug. 17	12 "
Clapp's Favorite	Aug. 2	9 "
Colonel Wilder	Oct. 2	11 "
Dearborn Seedling	July 19	1½ "
Doyenne d'Eté	June 28	2½ "
Doyenne d'Alençon	Oct. 17	4½ "
Doyenne du Comice	Oct. 16	11 "
Duchesse d'Angoulême	Oct. 17	13 "
Easter Beurré	Oct. 23	16 "
Forelle	Oct. 30	1 "
Flemish Beauty	Aug. 8	9 "
Glout Morçeau	Oct. 17	4 "
Howell	Aug. 21	4½ "
Idaho	Oct. 5	24 "
Jean de Witte	Oct 23	4½ "
Keiffer	Sept. 16	11½ "
Kennedy	Sept. 16	9½ "
Le Conte	Sept. 16	11½ "
Lawrence	Oct. 6	4½ "
Mt. Vernon	Aug. 28	7¼ "
Paradise d'Automne	Sept. 16	6½ "
Pound	Oct. 30	21½ "
Seckel	Sept. 16	3½ "
Sheldon	Oct. 17	3½ "
Swan's Orange	Oct. 17	3½ "
Vicar of Winkfield	Sept. 2	8½ "
White Doyenne	Sept. 16	10 "

In the above list the small size of such varieties as Swan's Orange will be observed. The surprising size of Idaho deserves especial note. Idaho, Pound, and Easter Beurré are always of the largest size common to the variety named. Pound is, of course, merely a kitchen pear, but the other two are of good quality for table use. In fact, as long as the trees remain healthy on this alkali soil, the fruit produced is excellent, except that it is often hard at the core.

Quinces.—This fruit does not much better its previous bad report, needing more water and less summer heat. Orange quinces were gathered October 13th; average weight, 6½ ounces; quality somewhat higher in 1901 than in former years.

Almonds.—Only valuable here for firewood. This nut has now been tested fully. The trees grow well in most cases. In 1901, Bidwell's Hardshell bore well here, but the crop was destroyed in 1902. In a few sheltered locations in the town soft-shell almonds bear crops, and around Lindsay and Porterville the almond does very well. On Mr. Tuohy's place in Tulare there is a good crop this year (1902).

Apricots.—The crop here is usually poor. In fact, the tree is commercially an entire failure and has been so almost every year. There has been a light crop about one year in four. The failure is due to the light frosts and to the cold, alkali soil. The fruit is also poor and small, as the following table of the crop of 1901 will show:

APRICOT STATISTICS, 1901.

Name.	Date When Ripe.	Average Weight.
Smith's Triumph	June 10	1¼ oz.
Early Moorpark	" 14	1¼ "
Gooley	" 14	1½ "
Flickinger	" 16	1½ "
Royal	" 16	1¼ "
Oullin's Late	" 14	1¼ "
Hemskirke	" 19	1½ "
St. Ambroise	" 19	1½ "

There are some excellent apricot orchards near Visalia, Farmersville, and Hanford, but the crop is generally a failure in the Tulare district.

Nectarines.—The trees sometimes bear about as well as peaches here, but seem a little more susceptible to frost, and the fruit is not first rate. The three best varieties are Hardwicke, New White, and Stanwick. The season of ripening ranges from July 24th to August 8th. Victoria, Lord Napier, Boston, and Newington have not done well. The largest nectarines grown here average 3½ ounces each (Stanwick).

Peaches.—There have been excellent crops for the past five years. Some seventy-five varieties have been tested here during the past ten years. There seems to be no need to experiment much with the Spanish and Southern types, as the Persian peaches continue to do well. The Chinese Cling and the Honey peach are good varieties here, and most of the Southern kinds will do as well as these. Still, as trees of the Persian varieties remain healthy and bloom and leaf out in a normal way, there is no demand here for different sorts, as there is in portions of southern California.

An amended list of the best varieties here includes the following:

Clings: Seller's, Grover Cleveland, Chinese, Oldmixon.

Freestones: Alexander, Oldmixon Free, Elberta, Lovell, Morris White, Muir, Noblesse, Pickett's Late, Salway, Wheatland.

As a rule, peaches grown here are not very large, as California peaches go. The best sorts as grown at the substation without irrigation (average rainfall less than 9 inches) are, however, of good canning sizes, and the trees are well loaded, requiring two thinnings in the spring. The fruits of such peaches average from 10 to 13 inches in circumference, according to the variety. Specimens of yellow clingstones from young orchards in the district have measured 18 inches in circumference. These were mere monstrosities, a few of which were found on fifty acres of trees.

The following table shows the dates of ripening and average size of the peaches on the substation:

PEACH STATISTICS.

Name.	When Ripe.	Average Weight of One Peach.
Alexander	June 10	5 oz.
Amelia	Aug. 9	9 "
Beer's Smock	Sept. 16	7¾ "
Belle de la Croix	July 31	3 "
Belle Douay	July 24	3½ "
Blood Cling	Sept. 26	6 "
Brandywine	Aug. 18	7¾ "
Burke Cling	Aug. 5	8 "
Chair's Choice	Aug. 18	9 "
Chinese Cling	Aug. 5	7 "
Cooledge's Favorite	July 19	3 "
Crawford's Early	Aug. 1	6¼ "
Crawford's Late	Aug. 21	7½ "
Early Rose	Aug. 18	5 "
Elberta	Aug. 4	6½ "
Golden Cling	Sept. 6	9 "
Governor Briggs	July 24	4 "
Governor Garland	June 10	6 "
Grover Cleveland	Aug. 21	7 "
Hale's Early	June 30	4½ "
Henrietta Cling	Sept. 16	9½ "
Jennie Worthen	July 3	5 "
La Grange	Sept. 18	7 "
Late Admirable	Sept. 4	7½ "
Large Early York	July 19	2 "
Lemon Cling	Aug. 31	4½ "
Lovell	Aug. 26	8 "
Mary's Choice	July 24	5½ "
McKevitt's	Aug. 28	9½ "
Morris White	Aug. 14	7 "
Mountain Rose	Aug. 4	5 "
Muir	Aug. 18	6 "
Newhall	Aug. 12	7 "
Noblesse	July 26	6¼ "
Oldmixon Cling	Aug. 12	4½ "
Oldmixon Free	Aug. 4	5 "
Pansy Pabor	July 19	3 "
Picquet's Late	Sept. 16	10 "
Richmond	Aug. 3	4 "
Rivers' Early Red	June 24	4 "
Roseville Cling	Aug. 28	8 "
Salway	Sept. 25	11 "
Seller's Cling	Aug. 28	9½ "
Schumacker	Aug. 28	4 "
Stump the World	Aug. 28	9 "
Susquehanna	Aug. 9	6½ "
Thissell's Free	Sept. 2	8½ "
Ulattis	June 13	6 "
Ward's Late	Sept. 16	6 "
Waterloo	June 12	4 "
Wheatland	Aug. 4	6½ "
Wilkins' Cling	Sept. 6	9 "
Wonderful	Sept. 18	7 "
Yellow St. John	July 14	4½ "
Yellow Tuscany	July 19	6 "

Plums and Prunes.—After years of experiment here it is certain that the plum stock fails in alkali; peach stock does better, but the fruit needs a cooler summer climate, a heavier loam soil, and more water. The crop of American and European plums is often large, and some varieties are of excellent quality. Plums and prunes succeed extremely well in some portions of the district where conditions are more favorable. Among the best plums and prunes here are Bavay's Green Gage, Czar, Coe's Golden Drop, Belle de Septembre, Reine Claude, General

Hand, Lawrence, Tragedy, Columbia, Prince Englebert, Fellenberg, Quackenbos, Cherry, and Robe de Sergent. The English Damsons, which for a time did well, are now a failure. The Japanese plums usually fail to escape frost.

The following table shows the time of ripening and average size of plums here:

STATISTICS OF PLUM ORCHARD.

Name.	When Ripe.	Average Weight.
Bavay's Green Gage	Sept. 6	2 oz.
Botankio	July 25	½ "
Coe's Golden Drop	Sept. 6	
Columbia	July 14	2½ oz
Czar	July 14	1½ "
Damas Noir	July 15	½ "
Damson	Sept. 5	½ "
Diaper Rouge	Aug. 3	1½ "
Duane's Purple	Aug. 9	1½ "
Fellenberg	July 16	1 "
General Hand	Aug. 25	2½ "
German	July 27	¾ "
Golden Prune	Aug. 3	1½ "
Green Gage	Aug. 3	1½ "
Guthrie's Green Gage	Aug. 9	1½ "
Ickworth's Imperatrice	Sept. 6	1½ "
Imperial Gage	Aug. 9	1½ "
Jefferson	Aug. 25	2 "
Judson	Sept. 25	1 "
Lucombe's Nonesuch	Aug. 8	2 "
Peach	July 14	1¼ "
Prince Englebert	Aug. 14	2 "
Prince of Wales	Sept. 4	1 "
Prune d'Agen (petite)	Sept. 6	1 "
Quackenbos	Sept. 6	2 "
Robe de Sergent	Aug. 29	1 "
St. Catherine	Sept. 26	¾ "
St. Lawrence	Sept. 6	1½ "
Tragedy	July 25	¾ "
Victoria	Sept. 6	1½ "
Yellow Gage	July 25	¾ "

The largest plums grown on the substation are Coe's Golden Drop, Quackenbos, and Peach, having average circumference of 6 inches, and General Hand, average circumference 7 inches.

Figs.—It has never been practicable to measure the fig crop. As it ripens, birds and visitors carry it off. In general terms, some varieties bear heavily every year, and a list of "best sorts" can now be offered with entire confidence. Hardiness is an important factor of success in this district. Nearer the foothills many varieties which fail here prove among the leading sorts. The frosts of 1901–2 severely injured a number of old trees. Hirtu du Japon is about the best of all the varieties grown here for table use; it is a delicious fig, a good bearer and quite hardy. Dorée Narbus is very early and a small but delicious fig. Ronde Violette Hâtive is an excellent variety, so is Brown Ischia. White Bourjassotte is a poor grower, but the fruit is first class. Du Roi is too tender for the district, and must, with reluctance, be discarded; it is strongly recommended for the foothills. Negro Larga, one of the largest and finest figs near the mountains, is also of doubtful hardiness here, although it bore well in 1901. The White Adriatic bears well every year.

The figs which, considered merely as trees, have grown best in the past fourteen years at this substation, are, named in order of value, the

following: Dorée Narbus, Hirtu du Japon, Ronde Violette Hâtive, White Adriatic, Brown Ischia, Bourjassotte Grise, Col di Signora Bianca, De Constantine, Pastiliere, Brown Turkey, and Bulletin Smyrna. Some of these do not bear well; others are of poor quality. The three most valuable table sorts for the district, all things considered, are Hirtu du Japon, Ronde Violette Hâtive, and Brown Ischia, all of which are better in quality than White Adriatic.

THE VINEYARD.

The value of the vineyard here is further noted under the heading of "Alkali Reclamation." Mr. Forrer, the foreman of this substation, has furnished some valuable practical notes upon varieties and cultures here, based on years of experience. There is, he says, a remarkable revival of interest in grape culture in the San Joaquin Valley, and much inquiry is made regarding the best sorts to plant.

One of the best, if not the very best, of all the grapes grown here is, in point of bearing quality, the Tinta Val de Peñas, a fine upright grower, yielding large bunches of grapes, ripening about September 1st, and producing a good wine.

Equal in quality of wine, but a shy bearer, and less thrifty in growth, is the Lagrain, which also ripens early in September.

Grenache is well worth planting in this district and on such soil it is a thrifty, strong upright grower, and a prolific bearer.

Next to this in point of value here is Carignane, a heavy bearer and a good grower.

Alicante Bouschet is also first rate, and so is Aleatico, Mondeuse, Charbono, Cinsaut, Aramon, Crabb's Black Burgundy, and Mourastel. The latter has yielded from 1,500 to 2,000 pounds for thirty vines every year since of bearing age.

Beclan, though not a good grower, is a heavy bearer for its size. It should always be grafted upon one of the most strong-growing varieties; then its value would be much increased.

Mourisco Branco, while very thrifty, is somewhat inclined to bear poorly.

The following black Italian grapes bear well and grow well: Tadone, Bolgnino, Paga debito, Bollina, and Quigliano. They can be strongly recommended here.

The following white wine grapes do well here, growing thriftily and yielding good crops: Golden Chasselas, Burger, Folle Blanche, Peruno, Malmsey, Beba, Mantuo de Pilas, and Palomino.

Other excellent grapes here are Bakator rouge, Massana, Barbarossa, Verdal, Napoleon, and Mission. These, with the varieties previously mentioned, are altogether the best grown at this substation as regards the three points: (*a*) resistance to alkali, all being on their own roots; (*b*) heavy bearing, and (*c*) thrifty growth.

SMALL CULTURES.

The list of small cultures at any given time at this substation has been short, but the range tested during a series of years has been great. Seeds sent by the Department of Agriculture are spoken of under the numbers in the Inventory as well as by species. Previous reports and

bulletins have from time to time given results with many different plants in alkali soils.

Plant growth here comes naturally under several heads, such as the following: (*a*) Drought-enduring plants, which yield to alkali of greater or less intensity;

(*b*) Plants which need more water than the natural rainfalls, and also suffer from alkali;

(*c*) Plants which need more water, but withstand large amounts of alkali;

(*d*) Plants which withstand severe drought and also a high amount of alkali.

Severe winter frosts still further increase the difficulties of plant life and reduce the number of "all around successes."

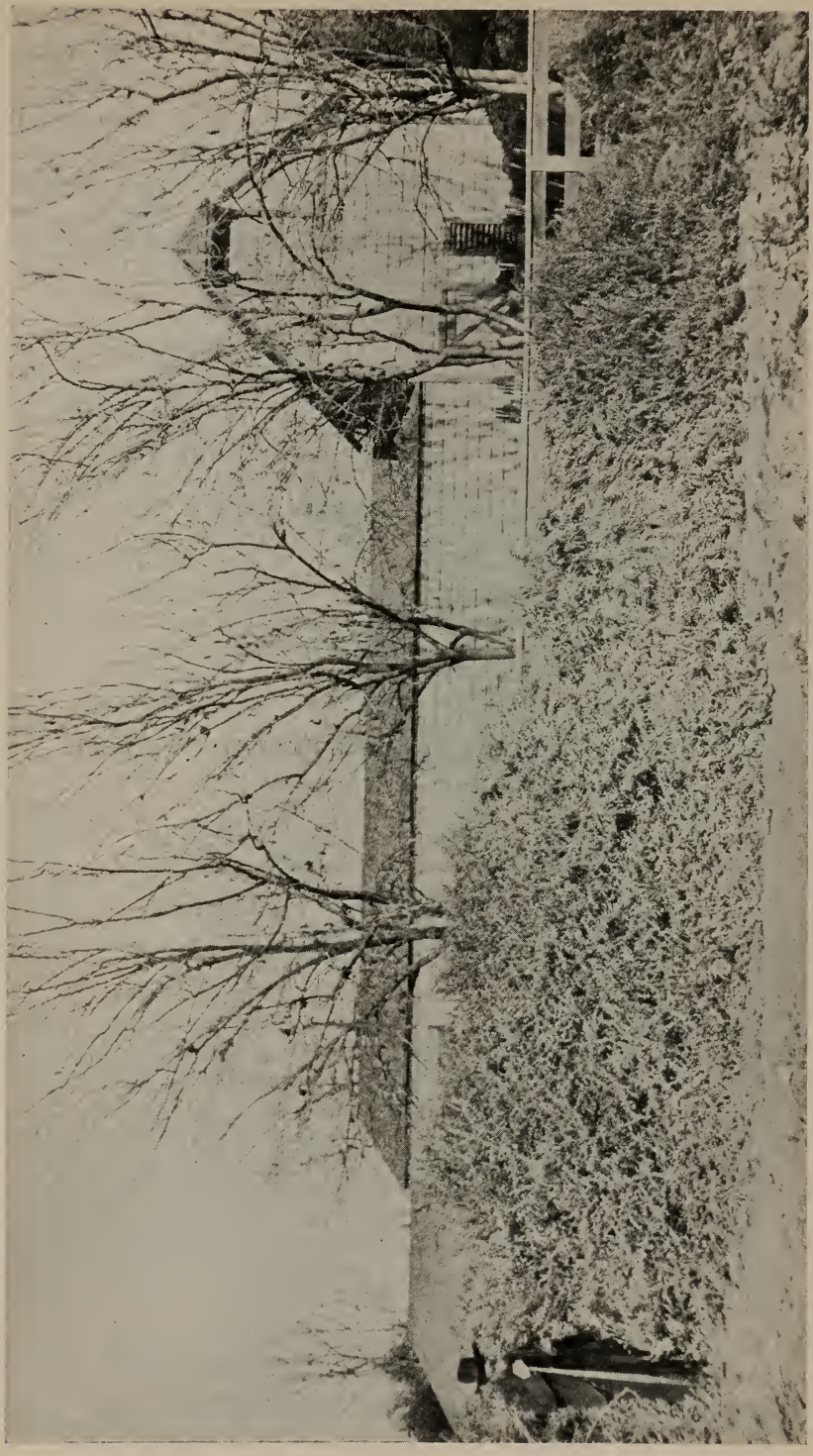
The Saltbushes.—It remains true here and at many other points in the San Joaquin where thorough tests have been made, that the atriplexes, rhagodias, and other saltbushes are of great economic importance. This has been so fully stated in previous publications, such as Bulletin No. 125, and elsewhere in this and in the previous report, that an extended paper is not now needed.

The opinion of the late Professor John A. Myers, for a long time Director of the West Virginia Experiment Station and for a number of years the American director of the work of the Nitrate Propaganda, may justly be quoted here. Under date of December 5, 1900, this able and careful man wrote from New York as follows, to Mr. W. C. Clark of San Bernardino. Professor Myers said: "I have no connection with the University of California, but I have been exceedingly interested in their experiments with Australian saltbush (*Atriplex semibaccata*). The work of the California experiment station in introducing and developing this plant for the use of the farmers of California is worth more to the State than the entire experiment station has cost since its beginning or will cost for the next fifty years."

As Professor Myers several times visited the substations, took notes upon the yield of saltbush forage, and was familiar with the analyses made here and elsewhere, his testimony is especially valuable. At that time, however, the tall rhagodia and still taller Argentine atriplexes had not been established at Tulare, and hence the trailing *A. semibaccata* was the leading species which he observed. It is still very important, but as many locations require a taller and more bush-like plant, the new *A. pamparum* in particular deserves wide testing.

As shown in the photograph (Plate 5), *A. pamparum* and *A. cachiyuyum* (which is quite similar) are very tall, strong plants, withstanding alkali in which grapevines have failed. If cut back as often as necessary, these new species make an enormous growth of fresh, soft forage, which has, by analysis, as high a food value as *A. semibaccata*. A large crop of seed was gathered in the winter of 1901–2, and experiment on a larger scale is now easy. But these Argentine atriplexes can also be grown from cuttings. Cut back in January, the stocks make new shoots twenty inches high, fit for forage in three or four months. This indicates, where there is sufficient water, at least three or four crops a year. The growth in warm weather will be much more rapid than in January–April.

The half-tall, shrubby atriplexes, such as *vesicaria* and *halimoides*, which several years ago seemed so entirely at home here, when last



Atriplex pamparum. Atriplex cachiyuyum.

PLATE 5. SALTBUSHES AT SAN JOAQUIN VALLEY SUBSTATION.

observed (May, 1902) were evidently failing and disappearing, under fair average conditions. They seldom reproduce from self-sown seeds and *A. semibaccata* easily "runs them out" and usurps the soil under field conditions. *A. leptocarpa* also yields to *A. semibaccata* in the field. In cultivated or hoed rows, *A. semibaccata* makes nearly three times as much fodder per plant or per acre as does *A. leptocarpa*, and the quality is about the same. *A. semibaccata* greatly surpasses *vesicaria* and *halimoides* in actual yield per acre. The saltbushes which are much better in points of growth and yield at Tulare than at the Central Station or at Paso Robles, are named in order of improvement: *A. semibaccata, A. pamparum, Rhagodia spinescens inermis.* All the saltbushes withstand much drought and alkali.

Turkestan Alfalfa.—Among the alfalfas growing here are plots of "common California alfalfa," of "German Lucerne," a very compact and large-leaved stock, and of Turkestan alfalfa, sent out by the Department of Agriculture (Nos. 1150, 1151, and 1159—*Medicago sativa* var. *turkestanica*). Little difference was noted among these varieties.

Three years' experience shows that while no alfalfa will withstand the droughts here and yield any summer forage, the roots of the *turkestanica* will live through the summer and give early winter feed. To some extent this is true of all unirrigated alfalfa in the San Joaquin, but the ravages of the gophers make its growth under such conditions useless. By June all the alfalfas, unless irrigated, cease growth and run to seed or die down to the roots. *Turkestanica*, like the other varieties, now receives irrigation. But the growth of the *turkestanica* is noticeably more compact than that of the common form; it has a larger leaf, more foliage, and shorter joints, hence it is an acquisition of considerable value. The alfalfas withstand considerable alkali when once a stand has been obtained, but need irrigation in this district.

Horse-Beans.—A number of forms of *Vicia faba* from different sources have been tried here for four years, in the hope that they would withstand the frost and make a good growth before the dry weather. As a rule, they have failed to mature seed, and have amounted to nothing. This applies to all the best European broad-bean varieties. A somewhat better result was obtained in the case of Nos. 7024 and 7035 of the Department of Agriculture.

No. 7024, "the Laidi horse-bean of Egypt," sown March 1, 1902, on medium but sandy alkali soil, proved to be very early. Plants were one foot high and had pods well set on May 1st. This variety is fully a month earlier than any other kind tested here.

No. 7035, sown at the same time, was beginning to blossom May 1st. A few plants were sixteen inches high, but the average was one foot.

The above tests were only partial, as these varieties should be sown with the early winter rains. Then if they withstand the cold and grow well, they will be an acquisition. But the seed was not received until the end of February. These two varieties justify field trials on better and less frosty soil.

The Vetches.—The best vetch here is the common bitter vetch (*Lathyrus sativus*), which has been tested for several years. At times, sown early and with favorable rains, it reaches a height of nearly one foot. Usually, however, as with No. 7639, sown March 4, 1902, on sandy alkali soil, it

blossoms when six inches high, and spreads very little. May 1st this plot was in full bloom. It will hardly ripen seed without irrigation, nor has it ever done so here, in ten years' experience. It is not suited to the soil and climate. Even with copious irrigation it hardly yields half a ton of hay to the acre.

Lathyrus tingitanus (No. 7637 of the Inventory), grown here from several sources at different seasons, does not endure the drought. It spreads three or four inches, and ceases growth by the middle of May or early in June.

Vicia villosa has been fully tested in plots and sown with rye. Its height ranges, according to the season, from two to four inches at time of blossoming. None of the entire list of vetches has succeeded here in four seasons of growth on this sandy, alkali soil.

In the spring of 1901, *V. narbonensis* (No. 7532) and *V. ochrus* (No. 7534) were given a careful trial. They were in blossom at the height of two or three inches, May 1st. Growth soon ceased and they died by June 1st. Vicias Nos. 1504, 1506, 1507, 1509, and 1514 were grown in 1899 and 1900, but were failures.

The Lentils.—*Ervum monanthus* (No. 7522), *Ervum lens* (No. 5419), *Ervum hirsutum* (No. 5418), and various forms of the common lentil all prove unsuited to the soil. Without irrigation they seldom reach bloom, and are hardly more than two or three inches high, even with irrigation. They are affected by a small amount of alkali and fail to mature seeds.

Garbanzos.—Under various forms this notable pea, *Cicer arietinum*, has had thorough tests. In recent years much local inquiry has been made about chick peas, Colorado peas, etc., and the hope has been expressed by various newspapers that this plant would be very useful here. The same thing has been said of the vetches and many other plants long ago grown and reported upon. The utmost growth that Garbanzos makes here, when sown early, is one foot, with a few branches. As a rule, its growth is but six or eight inches; it blossoms in May, and dries up, if unirrigated, by the middle of June. Nos. 7017 and 7021 of the Inventory, sown in the spring of 1902, made the above average growth. About half of the plants were killed or dwarfed by alkali.

Lupins.—Previous reports have contained much about lupins here. Their value is very doubtful, except on better soil and nearer the mountains, where native species do unusually well. Sown early at the substation they have sometimes made quite a growth, but very cold weather checks this. *Lupinus termis* (No. 7022 of the Inventory), sown March 1st, was approaching bloom May 1st (seed received late). It made only about one fourth as much growth as did the "Palermo White." The latter, which on May 1st averaged a foot high and was past full bloom, seems to promise value here (sown March 1st).

Cereals.—The growth of the gluten wheats continues here, and seed is usually sown in December. At present the plots include Fultz (No. 5493), Golden Chaff (No. 5486), and Theiss (No. 3823), with various removes from the original. Seed from each plot is sent to the Division of Chemistry at Washington, and the changes in the grain are noted. Bulletin No. 3 of the Bureau of Plant Industry contains a great deal on

the subject of the hard wheats, and other portions of this report note the work being done at substations where the development of starch is less rapid than at Tulare. The plants strengthen and tiller more with each remove from the original.

The barleys, ryes, and spelts have usually succeeded well here. No. 7531, rye, received and sown as late as March 1st, was in excellent condition on June 1st in sandy alkali, but early winter sowing is much better. No. 4281, the East Tennessee Giant Wheat, also sown late, has done fairly well here, considering the season.

Goat's Rue (No. 1456 of the Inventory), *Galega officinalis*, has been given a thorough trial. It stands drought quite well, but is not tolerant of alkali. Plants are six or eight inches high by August. With irrigation three cuttings can be made, but alfalfa is better in that case.

Sainfoin and Sulla.—Both these well-known plants, which have been grown here for ten years, resist considerable alkali. They need water in dry years if any yield be desired after July.

Millets.—Many millets have been grown here. One of the best varieties of *Panicum miliaceum* was No. 1387 from Turkestan, which resisted drought well in 1899 and 1900, and stood alkali better than wheat did on both heavy and light soils. This millet makes an excellent hay, and should prove profitable for this or for chicken feed. It is far superior to the common German Golden and other older varieties tested here.

Medicago arborea (Inventory No. 1896).—This shrubby legume, the Tree Medic, has been tested a good deal here and elsewhere. It would have considerable value if gophers would let it alone. They even prefer it to alfalfa. It stands much drought and considerable alkali.

Foxtail Furze Inventory No. 1446).—This form of the well-known Scotch gorse has now been grown here for three years. It is a remarkable plant in its resistance to drought and alkali, and yet is extremely sensitive to the latter as soon as its limits are reached, the leaves and young shoots turning yellow very rapidly. Sheep and cattle will not eat the branches, which are nearly as thorny as the common gorse, unless crushed between rollers.

Grasses, Clovers, Etc.—For the past four years about twenty-five species of grasses and clovers have been grown here, with the aid, in most cases, of some irrigation. Perennial Rye-grass is one of the best kinds ever tested. Named in order of resistance to drought and alkali, the grasses of next importance to this are Smooth Brome (*Bromus inermis*), Italian Rye, and Texas Blue (*Poa arachnifera*).

There are few more resistant plants of any value for forage than *Melilotus alba* (Bokhara clover). Started early, it needs no irrigation and has kept green in the driest seasons (less than four inches of rainfall in the year). This is the plant that is often thought one of the worst of weeds, especially in alfalfa fields, but it is a honey-producer, and range stock will eat it.

Artichokes.—The European artichoke (*Cynara scolymus*) has been tested here for several years on strong, heavy, alkali soil. Nos. 4345 to 4350 of the Department of Agriculture, as well as seeds from other

stock, were sown, and the results show that this plant grows about as well in strong alkali as does *Atriplex semibaccata*, and a great deal better than do Russian sunflowers.

Squashes and Melons.—A collection of squashes and melons was planted in 1901, on sandy alkali soil about as good as any on the substation. The plants, though making a start, suffered much. A few watermelons ripened in October, but were very poor in quality. All the vines were watered every evening, and were mulched. Some vines were watered by means of a sunk box into which water was poured. It seemed impossible to keep the melon vines growing well. The summer squashes did a little better. The Tsama or Khama stock-melon throve very much better than any other cucurbit, and were hardier, but even these suffered in amount of crop from alkali.

SOUTHERN CALIFORNIA SUBSTATION.

(In Chino Valley, reached from Pomona, Ontario, or Chino. Elevation of main tract, 856 feet; of moist-land tract, 800 feet.)

The substation work in the Chino Valley is being carried on at two points: (1) on a thirty-acre tract three miles southeast from Pomona (or about the same distance southwest from Ontario); and (2) on a ten-acre tract about two miles south of the thirty acres, and about a mile from Chino. The thirty-acre, or home tract consists chiefly of reddish mesa soil suitable for citrus fruits; about one fifth is gray gravelly soil from the wash of the Sierra Madre. The ten-acre tract consists of the characteristic dark loam so common in the lowlands of the valleys and along the coast.

Brief History of the Substation.—This substation was established in November, 1890. There was then an abundant supply of free water, delivered by gravity from the main reservoirs, supplied chiefly by flowing artesian wells. The average rainfall was then greater than it has been in recent years, and the winter floods even swept across a large part of the home tract (1890–91), enriching the soil. Since then the settlement of the valley and the development of great water systems have compelled resort to pumping not only at the substation, but generally throughout the district. The value of water has steadily increased, and its economical use has here become one of the leading agricultural problems.

When the station was founded, in 1890, the young orchards of the district were much more diversified than now. Nearly all kinds of deciduous fruits which prosper in northern or central California were planted by the land-owners and were doing well. Almonds, peaches, apricots, and prunes, as well as apples and pears, were being planted. Olives were considered more promising than anything else, and walnuts were thought desirable on the heavier soils. Citrus fruits were chiefly planted on highlands of the rim of the valley, east and north. The especial demands made upon the substation were for more knowledge of all kinds of fruit culture, particularly deciduous; also for information about sugar-beets, for drainage and reclamation of moist lands, such as the ten-acre tract, and, as one newcomer expressed it, "for whatever can be found out about the soil, climate, and productiveness of the Chino Valley, as few of us know anything at all about any part of California." Along these lines, to fulfill the demands of the community, the substation developed. While experimenting with all kinds of deciduous fruits on a large scale, citrus fruits, olives, figs, and other semi-tropic fruits received no less attention. The substation also bore its share in the rise of the great sugar-beet industry of the valley, testing many varieties, distributing seeds, and examining other beet lands. Its numerous other activities can hardly be stated in a paragraph; their record runs through previous reports.

From its establishment, this substation has been popular in the community, and the foreman has been in demand over a large extent of

country, as horticultural expert and local adviser. The number of real farmers, fruit-growers, gardeners, nurserymen, etc., who visit this substation is far in excess of the number visiting any other substation of the system, as the horticultural population is dense, and the place is very accessible. There have been many meetings of farmers' clubs here; farmers' institutes have been held at the substation; the local newspapers frequently send reporters out to see what is going on, and the influence of the substation seems to be increasing in all directions. Its location was fortunate in many respects. Though a purely citrus station might well have been further inland, the problem of choosing one point between Los Angeles and the desert where experiments could be carried on for the widest possible area was admirably solved by selecting the Chino Valley, which is adapted to the culture of a vast range of species of plants.

There has been but one change in the foremanship here since 1890, and this is one of the especially fortunate items in the history of the substation. Mr. McLennan, sent there in November, 1890, was superseded in 1893 by Mr. J. W. Mills, a former student at Berkeley, who is therefore the second-oldest foreman, in point of service, being surpassed only by Mr. Forrer, of the Tulare substation. Mr. Mills has been over a large part of southern California at farmers' institutes and otherwise, and is becoming a well-posted person upon practical topics of agriculture. He has been helped, during his entire service, by successive patrons of unusual agricultural knowledge—Mr. Gird, then owner of the Chino Ranch, Rev. C. F. Loup, and Hon. S. N. Androus; also by a large number of local specialists in olives, oranges, beets, and other crops of the region.

CLIMATE.

The climate of the Chino Valley has a well-deserved fame in southern California. There is not much difference, either in temperature or rainfall, between Chino, Ontario, and Pomona, the three leading towns of the valley, nor is the climate of these places much different from that of Riverside, Colton, and San Bernardino, farther inland, in another valley system, excepting as regards rainfall. In this respect the Chino region in normal seasons is less favored than the coast, and more favored than districts farther inland. The following table shows some comparative rainfalls at various places east, west, and near the substation:

Place.	1892–3.	1894–5.
Los Angeles	22.00 inches.	23.00 inches.
Pomona	20.97 "	20 43 "
Ontario	21.00 "	20.24 "
Chino	20.19 "	20.00 "
San Bernardino	20.29 "	14.85 "
Redlands	15.20 "	17.75 "
Riverside	15.06 "	11.65 "

At the substation, situated about equidistant between Pomona, Ontario, and Chino, the rainfall in 1892–3 was 19 inches, or less than at either point; while in 1894–5 it was 22.96 inches, or more than at these places, and nearly as much as at Los Angeles.

The rainfall at Los Angeles, according to the records of the Southern Pacific Railroad, the Weather Bureau reports, and other available records from 1892 to 1902, averaged 16.85 inches; that of San Bernardino for a slightly longer period averaged 14.94 inches. The average for the Chino Valley lies between these two, or about 15.50 inches, while that of

Riverside and Redlands falls below San Bernardino. There have been "wet years," such as that of 1883-4 (rainfall at Los Angeles, 38.22 inches), and "dry years," such as 1876–7 (rainfall at Los Angeles, 5.28 inches). Only the establishment of enormous systems of irrigation, supplementing the annual rainfall, has enabled these thriving communities to carry on such intensive horticulture.

At the substation the rainfall has been as follows:

Season.	Rainfall, in Inches.	Season.	Rainfall, in Inches.
1889–90 (mean of surounding towns)	22.25	1895–96	8.75
1890–91	12.55	1896–97	16.99
1891–92	14.32	1897–98	9.39
1892–93	20.72	1898–99	5.71
1893–94	11.18	1899–00	9.58
1894–95	23.00	1900–01	17.74
		1901–02 (to April)	11.41

The average annual rainfall for thirteen years has been a little more than 14 inches. The average of the four years, 1889–93, was 17.46 inches, but the average of the four years, 1895–99, was only 10.20 inches. As at Paso Robles and Tulare substations, the rainfall of the years immediately following establishment here was more favorable than the average of a longer period.

The climatic record of the substation since the issuance of the last report, which closed with June, 1899, is shown in the following table, which includes temperature, rainfall, and weather by months:

	Mean Temperature of Month	Maximum Temperature of Month	Minimum Temperature of Month	Greatest Daily Variation	Least Daily Variation	Rainfall During Month	Number of Clear Days	Number of Fair Days	Number of Days when Rain Fell	Number of Cloudy Days
1899—July	75.3°	102°	51°	47°	31°	.00	26	5	0	0
August	72.5	102	47	48	23	.00	22	9	0	0
September	75.7	106	49	48	21	.00	21	8	0	1
October	62.7	95	38	40	9	1.92	14	11	6	6
November	59.0	85	38	40	5	1.39	14	12	3	3
December	54.2	80	32	39	7	.95	14	11	3	6
1900—January	58.2	80	34	37	5	1.30	17	9	2	5
February	57.3	87	34	45	15	.05	9	17	1	2
March	61.7	93	39	46	14	1.02	8	19	2	4
April	57.9	86	35	43	7	.95	12	5	5	13
May	66.2	96	40	45	12	2.00	21	5	4	5
June	68.8	96	45	49	13	.00	13	16	0	1
For the year	64.9	92.3	40.1	43 9	13.5	9.58	191	127	26	46
1900—July	72.3	99	48	43	21	.00	18	12	0	1
August	70.5	107	46	46	21	.00	12	19	0	0
September	66.4	97	44	49	20	.00	17	12	0	1
October	63.8	96	38	48	15	.34	14	15	2	2
November	61.6	93	38	47	8	8.38	22	2	6	6
December	54.7	80	27	38	22	.00	19	11	0	1
1901—January	51.0	76	23	38	10	2.89	7	12	10	12
February	55.5	92	28	41	8	4.46	14	6	8	8
March	57.5	90	33	48	16	.48	24	7	1	0
April	59.5	85	33	43	10	.19	18	10	2	2
May	64.3	86	43	34	13	1.00	7	21	3	3
June	71.4	108	46	53	17	.00	11	18	0	1
For the year	62.4	94.4	37.2	52.9	15	17.74	183	145	32	37

	Mean Temperature of Month	Maximum Temperature of Month	Minimum Temperature of Month	Greatest Daily Variation	Least Daily Variation	Rainfall During Month	Number of Clear Days	Number of Fair Days	Number of Days when Rain Fell	Number of Cloudy Days
1901—July	76.7	104	50	51	28	.00	21	9	0	1
August	80.6	109	49	48	28	.00	18	13	0	0
September	68.1	92	44	45	18	.00	30	0	0	0
October	66.0	96	43	48	20	2.29	22	4	5	4
November	59.0	84	37	37	15	.00	15	13	2	2
December	54.2	83	24	42	15	.00	0	0	0	0
1902—January	53.0	86	28	43	15	1.92	19	7	4	5
February	54.0	81	30	37	11	3.35	16	5	6	7
March	55.5	84	31	41	16	3.85	9	12	7	10
April	------	------	------	------	------	------	------	------	------	------
May	------	------	------	------	------	------	------	------	------	------
June	------	------	------	------	------	------	------	------	------	------

IRRIGATION.

The amounts of water used to produce crops in the Chino Valley are, as a rule, extremely small. Waste has been reduced year after year, owing to the high cost of water and consequent improved methods. The deep-furrow system, followed by cultivation, is now practiced.

Amounts of Water Used.—Between January and the end of June, 1898, the orchard received 2,880,000 gallons of water; between June, 1898, and January, 1899, it received 3,710,000 gallons. This total of 6,590,000 gallons applied in practically fifteen months (since no water was artificially applied in October, November, and December, 1897) was distributed as follows, arranged in order of greatest use:

	Gallons.
Citrus fruits	800,000
Peaches	790,000
Grapes	770,000
Plums	730,000
Lawn, garden, nursery, etc.	687,000
Pears	625,000
Apples	500,000
Olives	490,000
Figs	350,000
Alfalfa	285,000
Forest trees	270,000
European lupins	190,000
Cherries	125,000
Almonds and apricots	78,000

Since the rainfall of this region between September, 1897, and April, 1899, eighteen months, covering the entire period during which this irrigation was used, was only 15.10 inches, and since the area to which it was applied was about twenty acres, the average of irrigation and rainfall (7.48 gallons equaling one cubic foot of water) was a trifle over 25 inches. The amount of water, of course, varied greatly in regard to different crops. The olives received in rainfall and irrigation but 22.70 inches, while the oranges had nearly 29 inches.

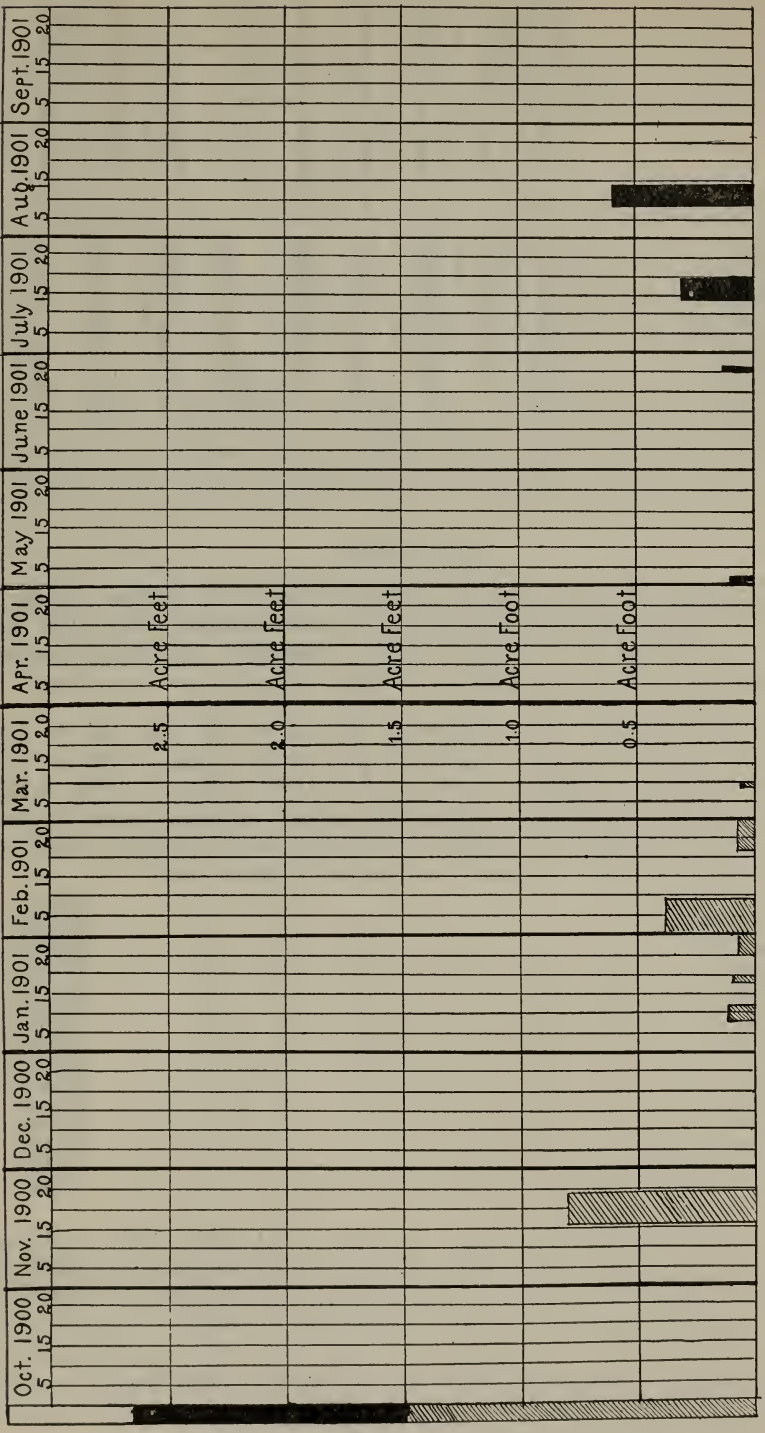


PLATE 6. Diagram Showing Irrigation of Orange Trees in Deep Furrows. Solid areas represent depth of irrigation; shaded, rainfall.

In the summer of 1900 the total amount of water used was 3,213,000 gallons on twenty acres, equal to about five inches of rainfall. The citrus trees received about three tenths of the entire amount of water used.

Irrigation in 1901.—During the season of 1901 the rainfall was greater than for two previous years, and the amount of water applied was also in some cases larger, as it was evidently needed by the trees. Experiments were made in the use of shallow and deep furrows. Records were kept in acre-feet and decimals thereof. The rainfall was nearly 17 inches, equal to 1.48 acre-feet.

Deep versus Shallow Furrow Systems.—The orange grove was divided into two portions, each irrigated by a different method. That portion on which the shallow-furrow system was applied required 1.167 acre-feet of irrigation (one extra irrigation), while the trees watered by the deep-furrow system required but 1.02 acre-feet. These points, with the dates and amounts of water given, are shown on the accompanying charts (see Plate 6, page 66).

The results of these experiments with deep and shallow furrows were interesting and valuable, justifying more complete discussion here. The first irrigation given to the grove was in the first week in July. The two east rows were irrigated from that time and through the whole of the season, in furrows twelve inches deep, while the three west rows were similarly irrigated, except that the depth of the furrows was but five inches. The soil had been deeply plowed twice during the six months previous and was in excellent condition.

How to Plow Furrows for Irrigation.—The methods of plowing furrows in an orchard are numerous, and many of them entail a large amount of extra labor in shoveling earth out of the intersecting points. The accompanying diagram will show the proper way in which to plow irrigation furrows, whether deep or shallow (see Plate 7, page 68).

In this diagram the surface is supposed to be graded so as to slope from north to south, and the water is to be applied on all sides to each tree, at the outer circle of branches, in the most economical manner. Therefore, first plow the furrows passing through *b* and *c*, running north and south. Next plow all the cross-furrows running east and west; then return and plow all the main water channels running north and south across the orchard. Two of them go down the center between the rows, and two more run close to the trees. The furrows will need some digging at the points *a*, *b*, *c*, and *d*, so as to have the water follow the trees (*a b c d*). The water is not allowed to run through the interrupted portions of the furrows shown by the dotted lines.

Absorption and Penetration of Water.—Mr. Mills reported as follows in regard to the application of water in these furrows: "After the water was once run to the end of all the furrows there seemed to be no difference in the amount of water taken in by the soil in the two sets of furrows. The water was longer in first reaching the lower ends of the deep furrows than it was in reaching the lower ends of the shallow ones. This seemed to be due to the soft soil rolling back into the deep furrows, which impeded the flow of water; but after this loose soil was once wet there was apparently no difference in size of the streams required to

reach the lower ends of the two sets of furrows. The entire orchard was irrigated at once; that is, the water was turned on all of the trees at the same time and kept running for the same length of time on them all until the irrigation was completed for each time, except, of course, in the case of the extra irrigation in June."

The absorbing capacity of the two systems of furrrows, deep and shallow, appeared to be about the same, but there was a very noticeable difference in the losses by evaporation. At one time, when water was running for eighty-four hours in all the furrows, the surface between shallow furrows became saturated. As soon as possible this surface was cultivated, but for days afterward it showed moisture every morning (an

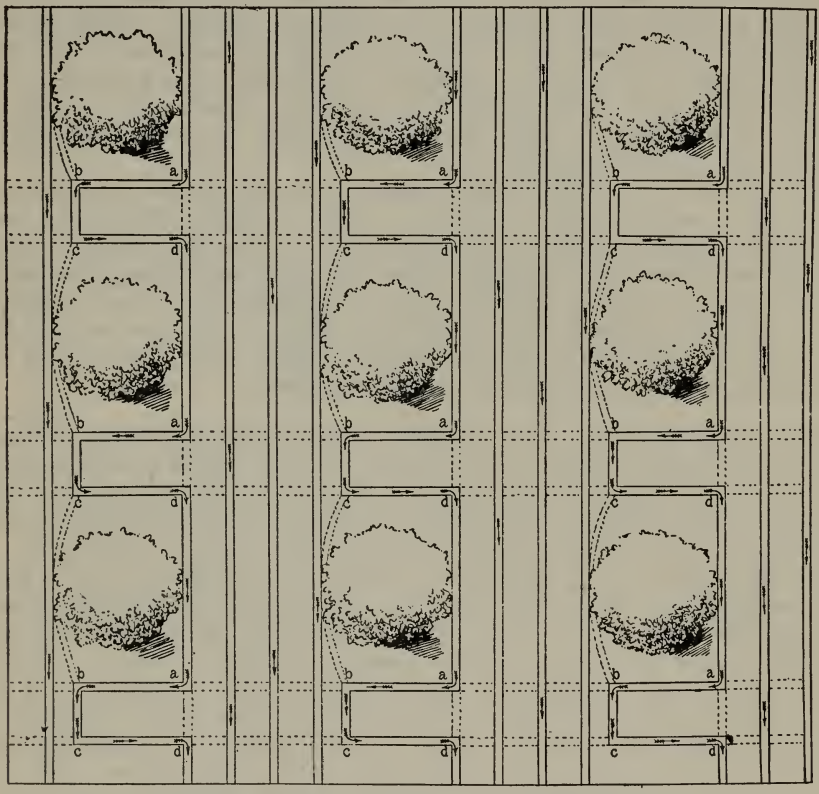


PLATE 7. How to Plow Furrows for Irrigation.

evidence of waste). In the case of the deep furrows, the surface soil showed moisture only near the head of the ditch, at the upper end of the rows, and immediately over the furrows, which of course had been filled as soon as practicable, as was also done with the shallow furrows. The moisture thus saved for the use of the roots by deep-furrow irrigation was sufficient to carry the trees from the first week in May until late in July. On the other hand, the loss by evaporation from shallow furrows compelled the foreman to give an extra irrigation in June. In other words, the trees irrigated by deep furrows went twenty days longer, thus saving cost of extra water and labor, besides keeping in better condition.

The penetration of the water sideways and downwards in the two methods used is very clearly shown by a diagram made by Mr. J. W. Mills, and used in his Bulletin No. 138, on Citrus Fruits. This exhibits cross-sections on the deep and shallow furrows, at different periods of time after the water was applied:

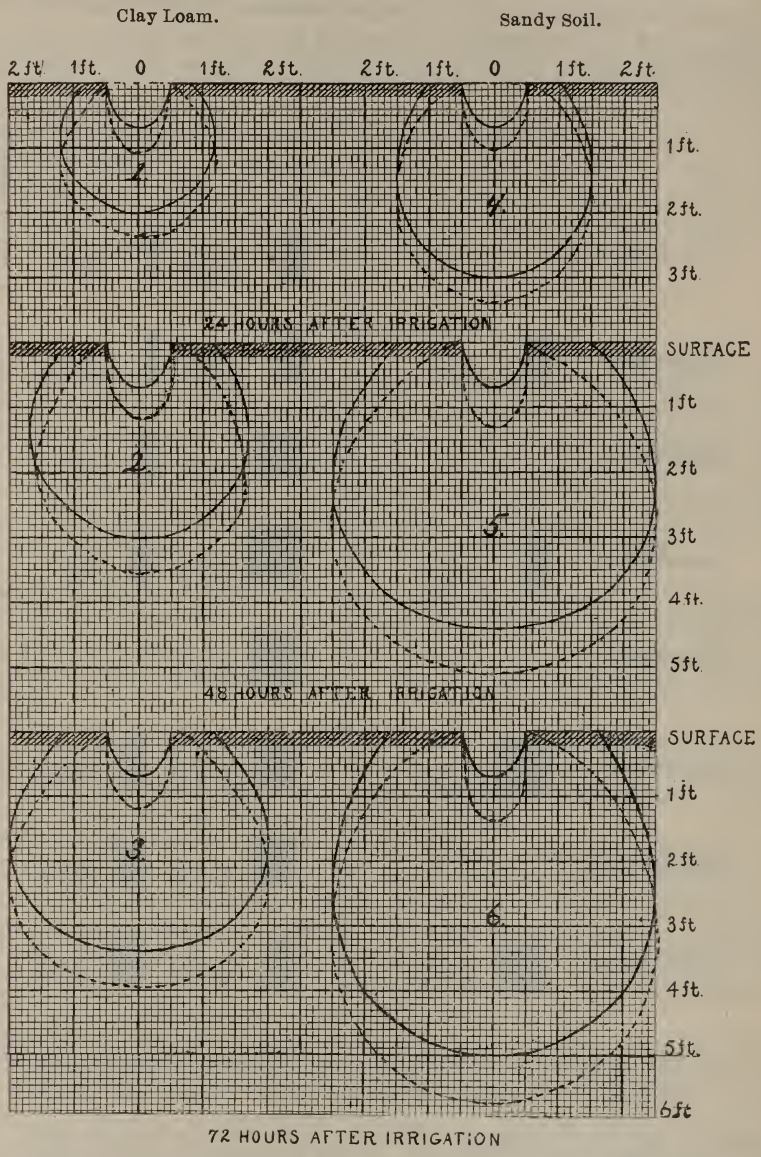


PLATE 8. Percolation Experiments. Spread of Water from Deep Furrows in Heavy and Light Soils.

The soil in and between the furrows was probed daily during these experiments. The spread of water was very slow. Even at the end of two weeks after irrigation the moisture lacked three feet of meeting in the wider spaces (13 feet) between the main furrows next to the trees.

Water applied to this strip close to the trunks of the trees would have been to a large extent wasted, and one aim of this experiment was to avoid waste as much as possible.

On the sandy-loam soil of the substation, the irrigation furrows should not be more than four feet apart; on the lighter sandy soil they are better if only three feet apart. The former soil does best with a "run" of seventy-two hours, and the latter with forty-eight hours, these periods saturating the soil five feet deep, which proved ample for citrus fruits, olives, etc.

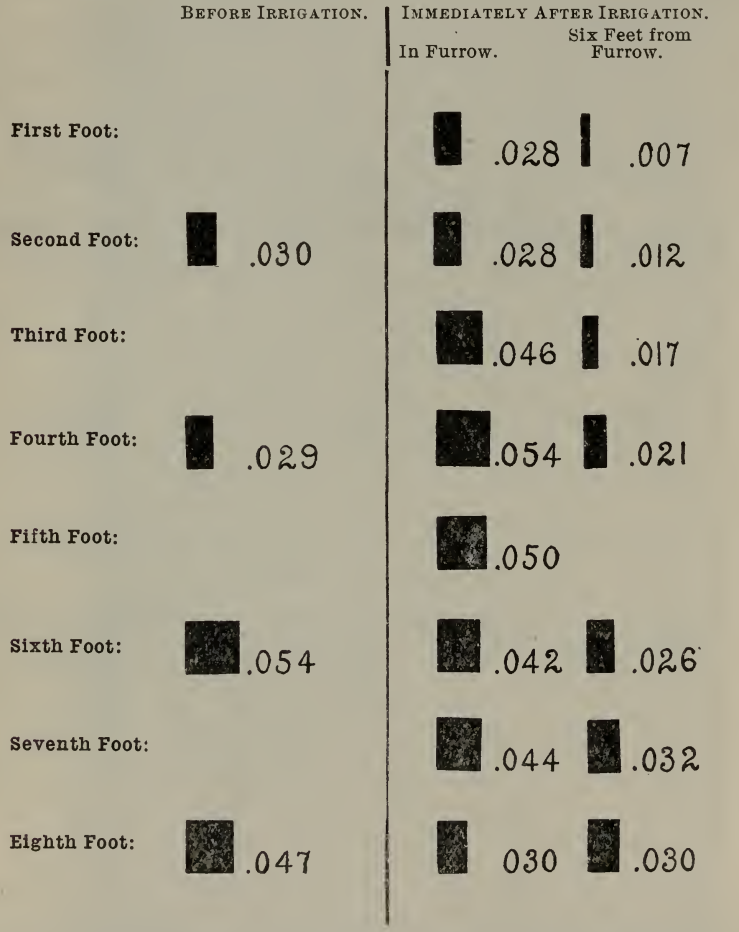


PLATE 9. Percentage of Water in Soil at Different Depths Before the Irrigation Season, and Immediately After Last Heavy Irrigation.

Weather during Irrigation.—The weather during the irrigation season was very warm. During the last week in June and the first week in July the daily maximums ranged from 90° to 108° Fahr. In fact, during the forty-five days after June 25th, the thermometer registered from 90° to 100° for twenty-nine days and from 100° to 108° for fifteen days. During this "hot spell," the longest recorded at the substation for ten years, the orange trees irrigated on the deep-furrow system did not suffer, but

those irrigated by shallow furrows, as above noted, began to suffer and were given an extra supply of water in June. The irrigation of August 9th, which the entire grove received, carried all the trees along for forty days, when those on the shallow furrows showed signs of distress. A shower of rain (0.45 of an inch), followed by a heavy rain (1.87 inches) a week later, ended the irrigation season.

Amount of Water in the Soil.—Determinations of the percentage of water in the soil at different depths before the irrigation season began and after the last and heaviest irrigation were made. The accompanying diagram (Plate 9) shows results. The first fifteen determinations—those in irrigation furrows—were made five days after the end of the irrigation of August 19, 1901, or eight and a half days after the water was turned into the head ditch. The last four determinations were made on May 1, 1901, just before the first irrigation of the season.

THE ORCHARD.

After six years of trial, it has become necessary to discard a large number of varieties of deciduous fruits grown at this substation, and they are being replaced with kinds which it is thought will prove better suited to this region. A bulletin upon deciduous fruit culture in the Chino Valley will probably be prepared at some future time, setting forth in detail the results of this extended experiment. The following brief notes show some of the observations already made here.

Apples.—In spite of irrigation when needful, frequent spraying, and, in brief, the most careful treatment, the greater portion of the varieties planted here are dead or dying, show blight, are non-productive, or, if bearing, have fruit of poor quality. The district is evidently unsuited to this tree.

The following varieties are badly affected with blight: Alexander, Arabskoe, Duchess of Oldenburg, Everbearing, Keswick Codlin, Mammoth Black, Marshall Seedling (Red Bellflower), McMahon White, Pewaukee, Perry Russet, Sweet Bough, Wealthy.

The following varieties are non-productive, or only yield fruit that is extremely poor (though in favorable locations these are excellent varieties); some of these also appear in the above list of blight-infected sorts: Amassia, Belle de Boskoop, Calvert, Duchess of Devonshire, Fameuse, Lady Lankford, Mammoth Black, Montreal Crab, Marshall Seedling, Nero, Perry Russet, Sweet Bough, Reinette de Caux, Red Bietigheimer, Twenty Ounce, Walbridge, and Yellow Siberian Crab.

Six varieties of apples appear to be absolutely blight proof, and are as far recommended for general planting as any can be in this district. These varieties are Early Ripe, Jonathan, Skinner's Seedling, Smith Cider, Rhode Island, and White Astrachan. Gravenstein is slightly affected with blight, but not seriously. Sonoma is a strong grower and a good bearer.

Other varieties which are worth further trial are Arkansas Black, Hoover, Lawver, Ortley, Red Astrachan, Shannon, Stump, White Winter Pearmain, Yellow Newtown Pippin, and York Imperial. A number of the newer Russian varieties have been planted, but are not yet in bearing. Many of the crabs have done poorly and some of the older Russian

varieties, but the list of useful sorts includes several, such as the Astrachans, that are Russian. About a hundred varieties have been tested first and last in this apple orchard.

Pears.—A very fine collection of pears was established here, and it included all the leading varieties, European and American. Many are now dead or dying, and in no case where two trees of a kind were planted have both done well. Beurré Clairgeau, Cole, Chinese Sugar, Duchesse d'Angoulême, Epine Dumas, Madam Loriel de Barney, Madeleine, P. Barry, and St. André, nine varieties in all, are retained, the last named, however, being of poor quality. These now seem reasonably free from blight and bear reasonably well, though trees of Beurré Clairgeau, Madeleine, Madame Loriel de Barney, and St. Andre have died from blight. In the cases, also, of Frederick Clapp, Clapp's Favorite, and Winter Nelis, one or two trees of each variety died from this disease. It may be said, therefore, that only Cole, Chinese Sugar, Duchesse d'Angoulême, and Epine Dumas have proved immune. Le Conte and Idaho certainly have not. The following varieties yielded to blight (two, and in several cases, three of each sort): Anne Ogereau, Augustin Daly, Bartlett, Baronne de Mello, Beurré Gris d'Hiver, Beurré Golden of Bilbao, Beurré Bosc, Bonne du Puits Ansaults, Brockworth Park, Court Queen d'Automne, De Tongres, Directeur Alphand, Duchesse de Mouchy, Exeter, Easter Beurré, Eugene Appert, Glout Morçeau, Gray Doyenne, Howell, Henry Fourth, Idaho, Jalousie de Fontenay, Louis Vilmorin, Levard, Marie Louise d'Uccles, Napoleon, Onondaga, Osband's Summer, Paradise d'Automne, Passe Colmar, Pitmaston's Duchesse d'Angoulême, St. Crispin, St. Michael, Star of Bethlehem, Souvenir du Congrès, Sarah, Tyson, Valliant, Vendée, Vicar of Winkfield, Winter Bartlett.

Plums.—The plum orchard contains 173 trees, some of them grafted to several sorts. All of the standard varieties, European, Japanese, and American, are represented here. Fourteen varieties are worth retaining from among the trees planted in the original orchard in 1891. These are: Botankio, Burbank, Czar, English Damson, Grand Duke, Kelsey, Normand's Yellow, Ontario, Petite Prune d'Agen, Rivers' Early Prolific, Satsuma, and Tragedy—besides Marianna for its bearing quality. Other varieties, either small trees or grafted into older stocks, which are doing well and in many cases promise to be very valuable here, are the following: Apple, Bartlett, Caddo Chief, Climax, Cherry, Chabot, Early Red, Evans' Seedling, Golden Beauty, Golden Drop, Honey Drop, Lone Star, Newton, Peach, Pool, Prairie Rose, Perdrignon, Rouge, Shiro, Sugar Prune, Sultan, Wayland, Wickson, Yosemite, and Yellow Onderdonk. The best of all these, and one of the most satisfactory in the entire orchard, is Wickson. Scions of this and of some other varieties sent out by Mr. Burbank, as well as of the best Americans, have been distributed from this substation in recent years.

We now come to the list of plums that, as experience has shown, should be discarded here by nurserymen and tree-planters. The following varieties are unproductive, although the trees grow well and are fit for working over to better kinds. Some of them are known to do well in other parts of southern California, but as a rule these old standard European varieties are not as successful in the southern counties as are the newer Japanese and cross-bred types: Autumn, Barry, Bassford,

Bavay's Green Gage, Bradshaw, Bulgarian, Brignole, Black Morocco, Belgian Purple, Columbia, Coe's Golden Drop, Coe's Late Red, Copper, Clyman, Duane's Purple, Datte d'Hongrie, Drap d'Or d'Esperen, Diaprée Rouge, Fellenberg, Green Gage, Glaister, German Prune, Goliath, General Hand, Imperial Gage, Ive's Autumn, Ickworth Imperatrice, Jaune Hâtive, Judson, Jefferson, Lucomb's Nonesuch, Lombard, Long-Fruited, Monroe's Gage, McLaughlin, Mont Barbat d'Ente, Prince Englebert, Peter's Yellow Gage, Puymirol d'Ente, Perdrignon Blanc, Précoce de Berthold, Pond's Seedling, Prince of Wales, Quackenbos, Royal Hâtive, Simon, Smith's Orleans, St. Catherine, St. Martin, St. Lawrence, Vineuse, Washington, Wangenheim, Wine-Sour, Yellow Egg.

Some, and indeed many, of the above varieties have never borne a plum since they were planted in 1891 and 1892. Their uselessness for this district is evident, yet many of these kinds are still being planted by newcomers.

Nectarines.—While some of the nectarines planted have borne as well as the average peaches, the fruit is not in demand and there is no interest shown in its culture. Downton and Stanwick have always had good crops; Elruge does well in some seasons. Lord Napier, Pitmaston Orange, and Rivers' Orange have never borne at all. Victoria bears very poorly, though receiving more water than the rest of the row.

Other Deciduous Fruits.—Peaches are elsewhere reported upon more at length. Seventeen varieties of apricots are grown, one and two trees of each kind having been planted, and some new California varieties have recently been added to the collection. The apricots have not borne fruit since 1899, excepting Royal, Briggs' White, Newcastle, Flickinger, and Hemskirke. The orchard as a whole is unprofitable; apricot culture is still on trial in this district.

There are ten varieties of cherries, representing all types (two trees of each), and fifteen varieties of almonds (49 trees). There are also 81 fig trees (usually listed among semi-tropic fruits), one and two trees of a kind, which collection includes about everything which has been fruited in any part of California, and embraces most of the varieties of Capri grown by Mr. George Roeding. There is also a large collection of Japanese persimmons.

CONCLUSIONS RESPECTING DECIDUOUS FRUITS.

The climatic limitations upon certain lines of deciduous fruit culture here are evidently decisive as regards commercial possibilities. But these limitations only apply to a similar soil, climate, or elevation in southern California, since the success of many of these varieties is well known in districts not many miles from the substation.

Almonds are of medium quality, but the trees have borne good crops only twice in seven years. The trees are extremely healthy.

Cherries have done even worse than almonds, and may be set down as an entire failure here. In fact, the cherry does not succeed anywhere over a large district hereabouts, and the Morello types are little better than the large standard sorts.

Fig trees, while growing very well, and in demand for cuttings to send to various parts of the State, do not bear first-class fruit, whether pruned or unpruned, irrigated or unirrigated, by reason of the "fig-sour," for

which no remedy has been found. A few sorts usually escape, such as Angelique, Bourjassotte Grise, and the common Mission Black.

Peaches.—Peaches form so important an item of the deciduous fruit crop that the history of this substation orchard is worth telling with more detail. The earlier reports of the substation show the great value of this crop; but in recent years, some of the Persian types having begun to fail, the orchard has been extended by adding a large number of Southern and other new varieties, which are now beginning to bear. Many of the old trees have suffered from root-knot. The following table shows the crop yielded in four successive seasons by the varieties named. All the trees were well cared for and irrigated when that was needful. Where two trees of a variety bore, the yield given is the average:

PRODUCT OF PEACH TREES, 1898–1901.

	1898.	1899.	1900.	1901.
Alexander	5½ lbs.	32 lbs.	0 lbs.	2½ lbs.
Amsden's June	20 "	30 "	15 "	15 "
Briggs' Red May	14 "	2 "	0 "	3½ "
California Cling	32½ "	50 "	5 "	30 "
Chinese Cling	22 "	20 "	10 "	20 "
Comet	117 "	33 "	40 "	60 "
Coolidge's Favorite	57 "	11 "	10 "	15 "
Crawford, Early	18 "	7½ "	10 "	30 "
Crawford, Late	60 "	15 "	10 "	15 "
Foster	97 "	18 "	22½ "	32½ "
Grosse Mignonne	32 "	10 "	10 "	37 "
Henrietta	35 "	20 "	30 "	30 "
Indian Blood	59 "	20 "	35 "	17½ "
Large Early York	60 "	20 "	10 "	73 "
Lewkins' Honey	(not bearing age)	35 "	40 "	30 "
Lovell	27 lbs.	25 "	30 "	30 "
McDevitt's Cling	16 "	0 "	0 "	5 "
McKevitt's Cling	54½ "	0 "	0 "	10 "
Morris White	25 "	0 "	0 "	15 "
Mountain Rose	37½ "	14 "	5 "	25 "
Muir	43 "	10 "	5 "	22½ "
Newhall	10 "	0 "	0 "	0 "
Oldmixon Cling	89 "	16 "	20 "	40 "
Picquett's Late	31 "	0 "	0 "	5 "
Runyon's Orange Cling	13½ "	35 "	5 "	20 "
Salway	41 "	30 "	40 "	60 "
Sellers' Cling	20 "	30 "	2 "	30 "
Smock's Late Free	55 "	15 "	47½ "	25 "
Stump-the-World	45 "	9 "	10 "	17½ "
Susquehanna	20 "	2½ "	1 "	2½ "
Ward's Late Free	11½ "	0 "	0 "	0 "
Waterloo	10 "	5 "	0 "	15 "
Wilkins' Cling	16 "	0 "	0 "	20 "
Yellow St. John	30 "	21 "	60 "	71 "
Yellow Tuscany	63½ "	8½ "	20 "	30 "

A glance at this table will show any orchardist accustomed to peach-growing on a commercial scale that very few of these varieties are yielding sufficient to pay for planting. When it comes to the question of small family orchards, quite a number of them are worth attention. The reduction in size of crop in almost every case shows the general unsuitability of the standard Persian varieties to this district. The only extremely early peach worth planting is evidently Amsden's June. Briggs' Red May, Alexander, and Waterloo are mere cumberers of the ground. Few varieties yielded more in 1901 than in 1898, and chief among these were Large Early York, Grosse Mignonne, Yellow St. John, and Salway. The falling off in the crops of such standard varieties as Crawford Late, Smock's Late, Foster, McKevitt's Cling, Muir, and Yel-

low Tuscany was remarkable. For the four seasons as a whole, Comet, Foster, and Oldmixon Cling were the best bearing kinds.

Salable Varieties.—The foreman reports that the following twenty varieties have given the most satisfaction: Comet, Crawford Early, Crawford Late, California Cling, Coolidge's Favorite, Ford's Improved, Foster, Lovell, Lewkins' Honey, Heath Cling, Henrietta, Muir, Mountain Rose, Runyon's Cling, Salway, Smock's Late, Seller's Cling, Stump-the-World, Yellow St. John, and Yellow Tuscany. The quality and appearance of all these varieties are unusually high. The only trouble is in the smallness of the crop in many cases. It is this difficulty that is being met by testing many new varieties of types other than the Persian.

New Varieties on Trial.—Among the new varieties now planted are the following: Angel, Admiral Dewey, Belle of Georgia, Beauty's Blush, Caton, Climax, Dwarf Japan Blood, Dorothy, Estella, Florida Crawford, Everbearing Francis, Peen-to, Red Ceylon, Suber, Waldo, Waddell, Victor, and Victoria.

Peen-to has proved to be a vigorous grower and very prolific, but the fruit is of poor quality and small, though severely thinned. It begins to show up on the fruit stands of Los Angeles, however, coming from the foothills, and its earliness makes it desirable. It is very subject to leaf curl. This variety has been known to ripen from ten to fifteen days earlier than the Alexander.

Angel, an improved Peen-to, a new Southern peach, is one of the best early varieties at the substation, and "bears heavily every year," so that it is to be recommended for general planting in southern California.

Honey (freestone), of the South China type, a very sweet medium or small peach, bearing some crop every year, even when the standard varieties fail, is being widely disseminated by the substation. So also is the old Chinese Cling, a North China variety, poor for canning, but a choice, well-flavored cling for other uses, and a regular bearer, even in unfavorable seasons.

The true Elberta proves to be one of the best peaches grown here. It makes a large, vigorous tree, bears well, and the fruit is of fair quality for a large, yellow variety.

Reviewing the subject of peaches for this district, we reach the conclusion that the Southern types grown extensively in Texas, Georgia, and Florida, are the most promising for future experiment, but that crosses upon the best Persian varieties, so as to obtain their size, firmness, and quality, will be required by the orchardists of southern California.

OLIVES.

From the commercial standpoint, olive-culture in this district in recent years has not been as prosperous as it was formerly. The olive crop at the fine orchard of the substation has been small for several years past. There are about 150 trees, including all the varieties grown in California. Less than half a dozen varieties, however, have been bearing well in recent years, although the trees receive the best of culture, have been fumigated to destroy the scale, and are well irrigated. Columbella, Mission, Rubra, Manzanillo, and Pendulina have been among the best-bearing varieties here. The value of this representative collection, which is now one of the best in California, is not lessened for

study and distribution to other districts by the fact of the non-bearing of so many sorts here.

Frost Effects on Olives, 1901-2.—The following notes upon the comparative hardiness of olives were taken by Mr. Mills, the foreman: The lowest temperature ranged down to 23° and 28° (in December and January). The crop of Ascolino was badly frozen. It was light, and the olives were ripe when the frost came, December 13, 1901. The crop of Santa Catarina was only slightly hurt. The fruit was ripe, but only that on the southeast side was damaged. Oblonga was very badly frozen. There were few olives on the tree. Regalis, Polymorpha, Picholine (true), and Macrocarpa all had ripe fruit, which was destroyed by the frost. Columbella had the ripe olives destroyed and the green ones badly injured. Manzanillo had both ripe and green fruit ruined. Præcox and Rubra bore a small crop, which was but slightly hurt. Nevadillo Blanco, Pendulina, Huff's Spanish, and Picholine St. Chamas, all with very small crops, were badly damaged. Cayon stood the cold well. The crops of Attica and Mission, the fruit on which was still green, were very little hurt by the frost. The Dalmatian olives were ripe and picked before the freeze. Redding Picholine bore very little, but stood very well. The above twenty varieties were all that had any fruit. No olives had been frozen at the substation in previous seasons. Most of the crop has been picked before the severe frosts, but the "left-overs" have not been frozen heretofore. The trees themselves have never been injured by frost.

CITRUS FRUITS.

Oranges and lemons have done well in recent years, and the grove is an excellent representative collection. The orange crop of the spring of 1899 was 5,847 pounds, from 58 trees; that of 1900 was 6,727 pounds, from 59 trees; that of 1901 was 8,671 pounds, from 54 trees; that of the spring of 1902, the season just passed, was 3,444 pounds, from 39 trees, the late Valencias not being ripe, and losses from splits and windfalls being greater than usual. The last estimate was made May 1, 1902.

Comparative Yields.—The following table shows the yields for four years of selected trees in the grove. Two trees of Washington Navel were taken. The large crops of some other varieties will be noted, which for home use here are excellent, although less valuable for market than Washington Navel. The average crops of all the trees in each case (last column) shows that Magnum Bonum and Pineapple have yielded much the best crops. The "good" tree of Washington Navel was one of six whose average was 154 pounds per tree per year. These six would therefore rank, in point of productiveness, as No. 5 on the list shown in the table, or below Ruby. The best tree listed ranks as No. 3 in the table, being surpassed by both Magnum Bonum and Pineapple.

COMPARATIVE YIELDS OF VARIETIES.

Name.	Crop 1899 lbs.	Crop 1900 lbs.	Crop 1901 lbs.	Crop 1902 lbs.	Av'ge per year.	Remarks.
Wash. Navel ——poor tree	23	110	88	63	71	Crop average of 12 trees was 96 lbs. per year per tree.
Wash. Navel ——good "	79	340	344	70	208	
Pineapple—— " "	246	286	375	127	257+	Crop average of 4 trees was 187 lbs. per year per tree.

COMPARATIVE YIELDS OF VARIETIES—*Continued.*

Name.			Crop 1899 lbs.	Crop 1900 lbs.	Crop 1901 lbs.	Crop 1902 lbs.	Av'ge per year.	Remarks.
Ruby	good tree		177	186	314	150	206+	Crop average of 4 trees was 156 lbs. per year per tree.
King	"	"	60	6	192	---	86	Crop average of 2 trees, as above, 64 lbs.
Tangerine	"	"	60	36	27	28	37+	Crop average of 4 trees, 3 years, was 43 lbs. per tree.
Jaffa	"	"	100	16	150	---	88+	Crop average of 4 trees, 4 years, was 64 lbs.
Homosassa	"	"	199	192	211	147	187+	Crop average of 4 trees, 4 years, was 165 lbs.
Valencia Late	"	"	53	119	188	54	103+	Crop average of 2 trees, 3 years, was 130 lbs.
Magnum Bonum	"	"	381	255	258	200	271	Crop average of 4 trees, 4 years, was 191 lbs.
Parson Brown	"	"	218	160	277	68	180+	Crop average of 4 trees, 4 years, was 153 lbs.
Malta Blood	"	"	35	165	320	84	151+	Crop average of 2 trees, 4 years, was 118 lbs.
Medit'an Sweet	"	"	132	50	271	136	147	One tree.

Frost Effects on the Oranges and Lemons.—The citrus fruits were noticeably hurt by the frosts of December 13, 1901 (23°), and January 29, 1902 (28°). On the 30th of January Mr. Mills noted the condition of the trees and made an excellent report, from which I quote as follows: The orange trees that are large and well-grown were practically uninjured, only the late fall growth being injured where it was exposed to the rays of the rising sun, causing the wood to die back to the last summer's growth. Young orange trees of last summer's planting were killed back nearly to the ground, even when wrapped with two thicknesses of Japanese matting. The trees of Kumquat, Kino-Kuno, and Oonshiu were not injured, but the fruit of the latter was ruined, all the cells being dried out on one side, even when not exposed to the sun. The effect of frost on the fruit of the orange is shown (1) by the drying out of the cells, (2) by the disintegration of the cells and the separation of the divisions of the pericarp in the center of the orange, and (3) by the shriveling of the whole fruit, rind and stem.

The first condition has heretofore been the most noticeable, but the second now seems to be more prevalent than usual. Fruit affected in the second way is full of juice, but it is thin, insipid juice, which is confined to the inside of the divisions of the pericarp, but is both inside and outside of the cells. Such fruit is soft and mushy inside, has a bad taste, and will not keep under any condition. The outside appearance of such fruit would indicate that it is first class except to an experienced eye. Majorca, Malta Blood, and Mediterranean Sweet seem to be most severely affected in this way, although the trouble extends to the Navel oranges in some of the Pomona groves.

The shriveled fruit (type 3) seems to be affected by the stem having been injured by the frost. Such fruit is heavy and full of juice, but the shrunken skin renders it unsalable.

The thick-skinned oranges of all varieties have the fewest empty cells. A striking example of the immunity from frost of thick-skinned and dormant oranges was afforded by a common seedling tree at the lower end of the grove, which had been gophered and had not made any growth last season. The foliage was so small and thin that the oranges could be seen all over the tree from any direction. The fruit was of ordinary size with rather a thick skin, but six weeks after the frost it

was heavy, full of juice, and of fine flavor. Specimens picked from the most exposed portion of the tree showed no ill effect from the frost. The trees have a healthy, green color, but the leaves are less than half the normal size. The foliage did not show any ill effect of the frost other than a dull appearance for a short time afterward.

St. Michael, Oonshiu, and King were the most seriously injured, most of the cells being dry. Tangerine (Dancy) had fifty per cent of the exposed fruit injured by the frost, but that in protected parts of the tree was uninjured. At the station the Washington Navel is injured most by the shriveling of the whole fruit.

Protection Against Winds.—The location of the substation, in the middle of the valley, renders some protection against wind storms useful. A number of eucalyptus trees grown at the Santa Monica station have, therefore, been planted on the eastern side, across the road, on vacant land belonging to the Chino Company, who gave permission, and will leave the trees as long as desired.

It is the general experience of growers that citrus trees need all available protection in localities subject to frosts or violent winds. Other things being equal, trees which have been injured by wind storms become more susceptible to frosts. Dense windbreaks improperly located may, however, serve to collect cold air, and so increase the frost injury to an orange grove. When an orchard entirely inclosed by a dense windbreak is situated on a slope, the frost damage as a rule increases toward the lower side. Sometimes the central portion is most affected, owing, it is probable, to insufficient irrigation. The lower end of a sloping orchard is likely to have a surplus of water, and the upper end gets some surplus from the head ditch, but the middle portion often suffers, and trees there may be severely injured by frost. In many cases it has proved useful to divide an orange grove into plots of two or three acres by windbreaks. The loss of land is considerable. Windbreaks, especially when intended to shelter larger areas than two acres, should not be too dense; trees planted in small clumps, or if in rows, with space between to let the wind pass, while somewhat breaking its force, are better than "tree walls" or hedges.

In many places, especially in a foothill country, it is practicable to study the wind currents and direct or modify them by planting masses of tall trees, even at a considerable distance from the orchard or house to be sheltered, instead of in a close, high wall around a few acres. In the middle of the Chino Valley, where all that is needed is some shelter against occasional wind and sand storms, a small block of eucalypts will be of considerable service in protecting the orange grove.

THE VINEYARD.

A large number of cuttings of valuable grapes continue to be distributed from the vineyard of the substation, which is about four acres in extent and includes nearly two hundred and fifty varieties. This season, shipments were made to many points, but the vineyard at Tulare still supplies more cuttings than any other substation. The experimental vineyards of the various substations now form the largest and most available collection of European grapes known to exist in the United States, and they have been drawn upon in recent years by various other stations and by foreign governments.

Grafting on Resistant Stocks.—In March, 1901, Mr. Bioletti, then viticulturist of the Department, went to the substation and carried on some grafting experiments on resistant roots of various sorts. The percentage of successful unions was low, owing to the injury of many young vines by the hot sun.

The principal work done was with Muscats; other small lots grafted were only to test the affinity which they might have with different varieties of resistant vines. In France the Bouschet grapes, it is said, have little affinity for resistant stocks; but some of the best unions made at the substation were with Alicante Bouschet.

In all cases the grafts were examined and any roots rubbed off from the upper scions in May and in July, when the raffia ties were cut. The ground was irrigated when needful. An excellent growth was made in most cases. Mr. Mills reports that "long grafts," that is, long cuts of an inch and a half at the point of union of the two scions, develop less knot than short unions do, and are in every way preferable. The following table shows results of this grafting:

GRAFTS ON RESISTANT STOCKS.

Name and Stock.	Number Planted.	Total Number Which Grew.	Number Which Made Good Unions.	Number Which Made Poor Unions.	Average Growth in 1901.
Muscat on—					
Rupestris St. George	680	95	60	35	9 to 14 in.
Rupestris Martin	374	89	69	20	9 " 12 "
Riparia × Rupestris 101	749	151	121	30	9 " 12 "
Riparia × Rupestris 3309	798	254	179	75	9 " 12 "
Riparia Gloire de Montpellier	50	7	7	0	9 " 12 "
Riparia Grande Glabre	58	8	8	0	9 " 19 "
Palomino on—					
Rupestris St. George	34	5	5	0	24 " 40 "
Riparia × Rupestris 101	38	5	2	3	24 " 48 "
Riparia × Rupestris 3309	38	8	7	1	24 " 40 "
Riparia Grande Glabre	34	3	2	1	24 " 40 "
Rupestris Martin	40	6	4	2	12 " 24 "
Feher Szagos on—					
Rupestris St. George	11	2	2	0	12 " 18 "
Rupestris Martin	11	0	0	0	-- --
Riparia × Rupestris 101	11	2	2	0	12 " 18 "
Riparia × Rupestris 3309	11	0	0	0	-- --
Riparia Grande Glabre	12	1	1	0	15 "
Sultanina on—					
Riparia × Rupestris 101	29	2	2	0	15 " 25 "
Riparia × Rupestris 3309	28	8	8	0	15 " 25 "
Rupestris St. George	28	2	2	0	24 "
Rupestris Martin	30	5	5	0	24 " 35 "
Riparia Grande Glabre	30	3	3	0	24 " 35 "
Sultana on—					
Riparia × Rupestris 101	12	3	3	0	16 "
Riparia × Rupestris 3309	12	3	3	0	16 " 20 "
Rupestris St. George	12	1	1	0	24 "
Rupestris Martin	(?)	3	3	0	15 " 24 "
Alicante Bouschet on—					
Riparia × Rupestris 101	17	5	3	2	10 " 18 "
Riparia × Rupestris 3309	18	9	9	0	15 " 24 "
Rupestris St. George	20	4	4	0	15 " 24 "
Rupestris Martin	20	1	1	0	18 "
Riparia Grande Glabre	20	1	0	1	12 "

New Grapes from the Department of Agriculture.—The department sent, in the spring of 1901, cuttings of ten new varieties of grapes, under Nos. 5908–5918. All these were grafted into ten-year-old vines of Bakator, and small pieces were rooted in the nursery. One variety, No. 5911, made a feeble growth and finally died, both grafts and cuttings, so that this kind is lost. The other nine varieties made first-class growth,

furnished from 80 to 279 cuttings of each sort in the fall of 1901, subject to orders from the Department. The longest cane of No. 5419 grew 15 feet in the season. Nos. 5909, 5910, and 5913 grew very late, and more or less of the wood was killed by frost; Nos. 5917 and 5918, like 5914, ripened thoroughly. Nos. 5915 and 5916 were only fairly well ripened.

One graft, that of No. 5913, which made a growth of 15 feet, bore two crops of grapes. One bunch was over a foot long. The fruit was dark blue with a tough skin. The vine was very prolific, and bore and ripened grapes till frost. Another variety that bore two crops was No. 5912, a fine white grape. Mr. Mills measured the growths made by these vines, one of each of the nine varieties grafted, and found that the total length of main canes and laterals was from 100 to 380 feet each, an excellent illustration of the rapidity with which grafts on strong, old vines develop under favorable conditions.

Notes on Table Grapes.—Mr. J. W. Mills, the foreman, furnishes the following brief, practical notes upon various varieties of grapes used here for the table, and some of them as noted for wine:

Alicante Bouschet is a favorite table and cooking grape in this locality, the bunches being of good size, and the vine a heavy bearer. It is also in demand with wineries.

Almeria is very late here, ripening in November and December. It is a shy bearer, and is not recommended for the sandy soil of the Chino valley.

Black Corinth is also late. The bunches are long (8 to 14 inches) and loose. The berries are a little smaller than those of Purple Cornichon, of good flavor when ripe, and keep well. This grape cracks but slightly under the early rains. Pruned long and tied to a stake, Black Corinth produced abundantly in 1901 (some vines 70 pounds), after having been killed back by frost on March 31st when the growth was 2 to 4 inches long, thus showing its hardiness.

Black Morocco is a good, late black grape of largest size; bunches medium size. It yields large second crop, and is recommended for this section.

Black Muscat yields large, poorly filled bunches (badly affected with coulure). It is of good quality, but is not very prolific.

Blue Portuguese is very early, the first ripe being in August, and is prolific, whether pruned long or short, so that we recommend it for trial in the Indio district.

Bowood Muscat is a slight improvement on the Muscat of Alexandria, and in fact, the best of the Muscats here.

Chasselas Rose is a general favorite, and is excellent for home use. Vine, bunches, and berries are small, but early.

Cinsaut holds its reputation in dry, sandy soil. It is very sensitive to frost, even when the buds are not yet open, but highly deserves trial in the Indio district.

Cipro Nero is the best late purple shipping grape here; ripens in November. The vines are prolific, whether pruned long or short. The bunches and berries are large and fine. Most of the crop was ruined in 1901 by early rains.

Emperor: The vine grows rankly, and produces well when young. Grapes are few, but all are large and well-shaped, though poorly colored and of inferior flavor. It can not be recommended for this section.

Flame Tokay is neither prolific nor very well colored here. The soil is too light for this grape.

Golden Queen is extremely prolific; the bunches are large and perfect. It is a late sort (November), and a good keeper. The bunches of this grape have the appearance of first-class Muscats, except that the shoulders are less prominent. It does not crack when rained on, but decays in small brown spots when prolonged wet weather occurs.

Gros Colman bears well and the berry is of good quality, but is smaller than elsewhere. The variety does not stand extremely warm weather, and the bunches are nearly all imperfect.

Luglienga is a white and early variety (July), and one of the shyest of bearers, but of good quality. It is not adapted to the sandy soil of Chino Valley.

Malaga is a very rank grower, but not prolific. Vineyards of this grape in this neighborhood have been taken out.

Muscat of Alexandria is a poor producer, and bunches imperfect.

Muscatello Fino is a poor bearer, but of best quality. The vines recovered well from frost in 1901.

Napoleon: This grape ripens in September and October. It is prolific; a sure cropper. Berries and bunches are of good size, and on the whole it is one of our best late white grapes.

Olivette de Cattane is about the best all-season white grape here. It ripens early in August, and holds its good quality until December. The vine is a strong grower, the bunches are full and large; it is moderately productive.

Pizzutello di Roma is a white, crescent-shaped, tender and crisp grape. Its seeds here are strong in tannin and not agreeable in taste; it is a medium bearer.

Purple Damascus is an early grape with large bunches and berries, but badly affected with coulure. The quality is not first rate. This variety is excellent for arbors but not for vineyards, but it would suit the Indio district.

Quagliano: This grape is of medium quality, but a poor keeper, and therefore not recommended.

Sultana is the best of the seedless grapes for this region.

Thompson's Seedless is a shy bearer, and not worth planting here.

Torok Goher Noir seems nearly identical with Gros Colman, but the berry is larger and the bunches are larger and more perfect. It is an excellent large black grape.

Trivata resembles Black Morocco, but is inferior in quality. It is very late, the second crop constituting the bulk of the product. It is spoiled by early rains every year, and is slow to recover from the spring frosts.

Verdal is a fine white grape, which ripens late (October or November). It is tender, and of fine quality. The vine is prolific, and a rank grower.

White Tokay is only moderately prolific, and not recommended.

Zabalkanski has long, imperfect bunches, ripening unevenly, and is always affected with coulure.

The list of Persian grapes includes some excellent sorts, but Alakahee, Ashanee, Rish Baba, and Hutab have imperfect bunches and bear poorly. Pizzutello di Roma resembles these, but is more productive and

has better fruit. Askaree is a very early Persian grape with medium-sized bunches and berries. The fruit is white and very crisp and sweet. The vine is not as rank a grower as other Persian varieties. It is worthy of trial in Indio. Black Shahanee is early (August) and very prolific; its bunches are of good size, but the berries are less than medium. This also is worthy of trial in Indio. Chavooshee ripens in September; it has large, long, loose bunches, and the berries are the size and shape of Cornichon, and white, crisp, and of good flavor. Khahallee also ripens in September. The bunches are medium; the berries are of good size, bluish-black, pointed, and very crisp and sweet. It is a favorite with all, and can be highly recommended. Payhanee Razukee is a red, early grape, a poor producer, and badly affected by coulure. It is very attractive when grown and might do better in Indio. Persians Nos. 20, 22, 23, 24, 25, and 26 are always barren, although the vines make a prodigious growth. No. 21 produces a few fine bunches of large-sized grapes, earlier than Thompson's Seedless by two or three weeks.

American grapes are more or less in demand in southern California, and cuttings are often asked for.

Agawam ripens in September. It is a reddish-brown, large grape of extra fine flavor and is moderately prolific.

Aminia ripened on August 8th. It is a large black grape with heavy bloom, and of good flavor.

August Giant ripened on August 15th. It is a large purple grape and unproductive.

Brighton ripened on August 5th. The fruit was above medium size, sweet, of good flavor, and very tough.

Brilliant ripened on August 10th. The bunches were small and close, of dull red color, good flavor, sweet, tough flesh, and tender skin. It is very prolific and bears a heavy second crop.

Campbell's Early ripened on August 5th. The fruit is purple in color, of large size, mild flavor, and sweet with moderately tough flesh. This variety yields a very large crop.

Dr. Hexamer ripened on August 10th. The fruit is reddish, with heavy purple bloom; quality is poor.

Governor Ross ripened on August 5th. It is a white grape, of medium size, and delicate flavor.

Green Mountain ripened on July 20th. The fruit is white, small, sweet, and moderately tender.

Herbert ripened on August 12th. It is a large, reddish purple grape and a good bearer.

Lindley ripened on August 10th. It is a bright red grape, above medium size, with tough skin, tender flesh, and good flavor.

Moore's Diamond ripened on August 5th. It is a white grape, of medium size, fine flavor, sweet and tender.

Rockwood ripened on August 8th. It is a small, black grape with heavy blue bloom; flesh tough, sweet, and of good flavor.

In the above list of American grapes Campbell's Early and Agawam are the two best varieties for this locality. Moore's Diamond is better than the average in all respects, and Governor Ross could be recommended excepting for its shyness in bearing.

SMALL CULTURES.

At this substation, a large number of the varieties of seeds sent out by the Department of Agriculture have been tested at various times, on both the home tract and the moist land. Some had been previously grown here, and others were new to the district.

Alfalfa.—This crop is one of great importance in the district, and more is sown every year. It usually does well on the ten-acre tract without irrigation, though dodder, and in a few spots strong alkali, have injured it. On the home tract irrigation is needful. The Turkestan alfalfas sent out by the Department have proved a valuable acquisition. Nos. 1150, 1151, and others of the Hansen collection were sent here in 1899, and have been tested ever since. Planted in the spring of 1900, Nos. 1150 and 1151 were 6 inches high by July. At first no difference in growth between these and the common alfalfa could be observed. Gophers destroyed a good deal of all the alfalfas this year, as in spite of all efforts to poison them, they "came in" from the surrounding fields, which were barren. Turkestan and other alfalfas were again sown in 1901. At the end of March, 1902, the Turkestan alfalfa was twice as high as the common kinds under the same conditions, both plants several years old and the younger plants. Sown on the dry land of the home tract, both Turkestan and common alfalfa died from drought. On any good alfalfa land here, the Turkestan varieties soon take the lead. At Paso Robles substation, the Turkestan alfalfa was not as large as the common alfalfa, but stood drought better, although here a local variety was even better in regard to drought-resistance.

Asparagus Chicory (*Cichorium intybus*), No. 4360.—This was planted on the moist land of the ten-acre tract. It grew 3½ feet high. The rosettes of much-thickened leaves were not locally in favor when cooked, a great variety of vegetables being easily grown in the district.

Bassia dallachyana.—This is an erect undershrub whose fruiting calyx is covered with a dense cottony substance. It has been suggested that this might be valuable for cotton or felt. Seeds were sown in the greenhouse, spring of 1901, and transplanted to the field, home tract, where they grew vigorously and are 3 feet high or more. Sheep eat this plant readily, but Dr. Koch says when in fruit it is injurious to livestock.

Broad Beans (*Vicia faba*).—These hardy beans, justly becoming popular in the coast valleys of California, have now been tested for several seasons at this substation both on the home tract and the ten-acre plot. A complete collection was obtained several years ago from Vilmorin and another from Sutton. Nearly all the Department of Agriculture importations have also been tested (Nos. 3628, 3751–58, 1453, 1454, and others), with the same results. Where early autumn sowing and winter irrigation can be practiced, the broad beans are worthy of further trial, but not for ordinary field conditions in this district.

Broccoli.—Nos. 4355–9, five varieties from Naples, Italy—the Purple Navidad, Santa Teresa, White San Isador, San Martinari, and Gennarese—were sown March, 1900, on the ten-acre tract. They came up well, but many were killed by alkali while the cotyledons were still

expanding. The few that remained made a poor growth, it being a very dry year. Nos. 4482 and 4483, also from Naples, and planted about the same time on the ten-acre tract, were also much injured by alkali. The tallest plants were 2 feet high. Autumn-sown broccoli and cauliflower suit the district admirably if planted on any fairly good soil.

Burdock (*Lappa major*).—One variety of this plant, used in Japan as a vegetable, was grown at the substation, on the home tract, several years ago, and grew very well. Nos. 4981, 4982, and 4983 of the Inventory were grown in 1900 and 1901 on the ten-acre tract, where the alkali destroyed the plants.

Carrots.—Eight varieties of field and other carrots were grown on the moist land in 1901. They stood the alkali fairly well, but the yield was surprisingly low for a soil which yields so well in beets. The yield of the best per acre was as follows: Long Horn, 4.25 tons; Large White Vosges, 3.75 tons; Improved White Short, 3.25 tons; Large White Belgian, 1.5 tons; Red Meaux, 1.25 tons; Long Red Aldringham, .75 of a ton. The ordinary yield of Long White Belgian on such soil as this, but free from alkali, should be not less than 12 tons, and in any case the yield of the White Short would be much less. The above results are probably traceable to the evil effects of alkali, which were greater on the deep-rooting sorts.

Chards (*Beta vulgaris*).—This, the "Swiss Silver-Ribbed," Nos. 4361 and 4362 (curled), was planted on the ten-acre tract. Both varieties suffered from drought and blight. The Chilean scarlet and Chilean yellow (both classed with the chards), more often used for ornamental purposes, Nos. 4363 and 4364, have also been grown here in previous seasons and have thriven very well. As a rule, there is little blight on any variety of beet. March 28th was the time of planting these chards in 1900.

Cotton (Egyptian varieties).—In previous reports will be found notes upon large collections of cottons, chiefly upland, grown here. The Section of Seed and Plant Introduction, now a part of the Bureau of Plant Industry, sent out in January, 1901, four varieties of Egyptian cotton (Nos. 3991, 3993, 4330, and 4329) for trial here. No. 3991 was the noted Jannovitch, which originated as a sport from the Abbasi, and was brought to notice in 1897. It is said to be the finest long-staple cotton ever produced in Egypt. No. 3993 is also a fine, silky, very long, white staple, and the variety is derived from the Mitafifi, which, however is a brown-fibered variety. No. 4330 is the Abbasi, a long-staple white cotton, which brings the highest price of any Egyptian variety.

The seed received from Washington was old, and thick planting was advised. The previous rainfall of October and November, 1900, was 8.72 inches; of January and February, 1901, 7.36 inches; of March, April, and May, 1901, only one inch. May 20th the cotton was planted in hills 4 feet apart each way. The stand was very poor, only about half of the hills showing a plant. A portion of the ground, where an alfalfa field had been plowed up, gave an excellent stand. No irrigation was given, but the cotton plants grew well until the frosts killed them to the ground. They were cultivated three times.

This Egyptian cotton bloomed August 1st, but all the early flowers fell and only those which came out about September 1st set bolls. Only

a few of these ripened, but sufficient seed was obtained for planting in 1902. A few hills of Doughty's Extra Long, a Southern variety, were planted for comparison. Under the same conditions, the Egyptian far outgrew the American cotton. On the driest land it was 18 inches high; on the best land, fertilized by plowing-under alfalfa, it was 4½ feet high. All the Egyptian varieties rooted much deeper here than did the American sorts, and it seems in this respect much healthier and better adapted to California conditions. But the season is very short for them, and early planting is needful, although acclimatization may do much in this respect. They require close planting to induce a more upright growth and to better protect them from the winds, as they seem to split more easily than do the common varieties. On the best soil, the bolls were as large as the average cotton grown here. Unlike the Peruvian cotton, which has never succeeded at any of the substations, the Egyptian varieties justify more extended trials and comparisons with more of the approved Southern varieties.

Cucumbers.—No. 4989, received under the title of "cucumber from Japan," produced a long, yellow, sour, muskmelon-like fruit. No. 4990 was a poor cucumber, also from Japan. The soil at the home tract, in years of ordinary rainfall, is well adapted to the growth of cucumbers and melons of every sort.

Enchylæna tomentosa.—Seed of this "drought-enduring undershrub" from Australia (No. 4287 of the Department) was sown in the greenhouse, and plants put in the open ground of the home tract, but all died, although some were watered every few days.

Field Peas.—No. 1486, the "gray winter field pea" of France, was planted on the home tract in 1900; it suffered from drought and made poor growth. The roots showed no tubercles. No. 1173, the large Victorian field pea, sowed November, 1899, made a brilliant record as regards growth, reaching by April, on the home tract, the height of 3½ feet. It showed value as a green-manuring plant for early sowing. This pea does not make much seed here, hardly yielding as many peas as were planted, but in moister soil would doubtless yield well.

Gourds.—No. 4999, the well-known "wax gourd" (*Benincasa cerifera*), planted April 30, 1900, failed to grow by reason of drought. Other tests of this vine show that it needs warmer nights, and thrives in few places in the district. No. 5000, a Japanese gourd, ripened a few small fruits, but did poorly. A large collection of some twenty varieties and species of gourds and ornamental cucurbitaceæ from various sources was grown here in 1891–93 and seeds locally distributed. The district is very well adapted to these vines, which require no irrigation except in years of short rainfall.

Grasses.—Seed of *Bromus inermis*, No. 3004 of the Inventory, was planted in 1900 on the home tract with Schrader's brome-grass (*Bromus unioloides*). The former scarcely lived and was only 3 inches high by winter; the latter grew a foot high, produced seed and made a good stand. Planted on the ten-acre tract of moist land, *B. inermis* made no showing at all as compared with *B. unioloides*.

Millets.—No. 2795, sown on the ten-acre tract in May, 1901, suffered from alkali and only grew 8 inches high. This was one of the broom-

corn millets of the Carleton collection from Russia. No. 1387, a Turkestan millet of the Hansen collection, grew but 8 inches high and headed out. It was on the ten-acre tract and suffered from alkali. Millets of every type have been successfully grown on the home tract in previous years.

Muskmelons.—Nos. 3161–64, 3173, and 5774 of the Department were sown in May, 1899, on moist land along the line of the head ditch, but as the water-flow ceased, all the vines died from drought, the rainfall of that season being very small. Nos. 6363 and 6364 were planted in May, 1901, on the home tract, but most of the vines and fruits were destroyed by rabbits and crows. The remaining fruits "split open, because of heavy fogs." A large collection of muskmelon seeds from Turkestan was received. Ten varieties, under the numbers 114, 115, 116, 117, 118, 119, 120, 121, 122, and 123, were distributed in the spring of 1899. None of the twenty or more kinds of these Asiatic melons, as grown at this substation, on sandy soil, unirrigated, proved of high quality compared with the best American and European varieties. All were more or less subject to fungous diseases of the leaves. Some did not bear well. Those distributed were the most healthy and the best bearers. In 1899 the Persian melons failed by reason of drought. In 1900 only a few varieties were planted, and, as before, the vines showed fungous diseases. This was true of vines from all the districts of Turkestan, old and new Bokhara, Kiva, and Amudaria. The Russian muskmelons which proved so successful at some other stations were not received here.

Myoporum montanum.—Seeds of this, the "myrtle bush" of South Australia, a large, edible-fruited shrub (No. 4300 of the Inventory), were sown in the greenhouse and transplanted. The bushes, when 3 feet high, were killed to the ground by the frosts of December, 1901, but have grown again from the roots.

Rye.—No. 1342, the Winter Ivanof of northern Russia, was planted in 1899 on the home tract. The season was exceedingly dry and the grain had no irrigation. Wheat No. 1181, from Turkestan, failed to mature, but rye No. 1342 grew 5 feet high. The seed did not germinate well, and hence the stand was poor.

Safflower.—Seeds of this well-known dye and oil plant (*Carthamus tinctorius*), No. 1345 of the Inventory, were sown on both tracts. On the dry land (home tract) it grew 3 feet high and produced some seed; on the moist land the crop was very large, the plants being 4 feet high. It produced seeds at the rate of 5,500 pounds per acre. The drought-resistance of this plant appeared considerably greater at Paso Robles than at this substation. It thrives over a large part of California, and is of very easy culture.

Sesame.—This famous oil plant of the Orient has been tested on a number of occasions at the substation and has done poorly. Seed sown on the home tract in the spring of 1901 (No. 1386) grew only 2 inches high.

Sorghums.—Nos. 4308, 4309, 4310, 4311, and 4312 were grown in 1900 on the ten-acre tract. None of them made a larger amount of fodder than the varieties previously planted here.

Soy Beans.—Nos. 4912, 4913, and 4914, imported from Japan by the Department, were planted in the ten-acre tract. They matured in succession. No. 4912 began to ripen seed August 15th; No. 4913 by September 10th, and No. 4914 by October 1st. The soy beans have done extremely well for several seasons, and all available sorts have been sown. The early and medium early varieties, although not yielding as heavily as the late in some years, are the safest for general planting here.

Sugar Beets.—No. 3941, the White Improved of Vilmorin, imported by the Department for coöperative experiments under the direction of the Division of Chemistry, was grown in 1900, and the beets shipped to Washington.

Sweet Fennel (*Fœniculum dulce*).—In the spring of 1900, Nos. 4367, 4368, 4369, 4370, 4484, and 4485 were sown on the ten-acre tract. These were all fine Italian varieties. Only a few specimens of each variety survived the alkali, but these prospered and grew to a height of 4 feet. These varieties were again sown in the spring of 1901, but alkali prevented growth. In good soil, this plant thrives here. In 1900 it grew well with a rainfall of only 9.58 inches.

Tribulus hystrix.—This is an annual herb from South Australia, considered there a very useful fodder plant (No. 4301 of the Inventory). The seeds sown in the spring of 1901 grew readily, but the plants developed slowly and have not made seed.

Turnips.—No. 4968, a turnip from Japan, was sown on irrigated ground, April 30th. It "ran up to seed almost immediately." Turnips sown here with the early rains in October or November are excellent.

Vegetable Marrows.—Several varieties of this form of *Cucurbita pepo*, so well known in Europe and used as "summer squashes," have been grown for two or three seasons. Nos. 4365 and 4366 from Naples were planted early in May, 1901. In 1900 these two varieties and also the former collection sent out by the Department (Nos. 3132, 3133, 3136, 3137, 3141, 3145, 3148, etc.) had been grown. Seed of four of the most distinct have been distributed. These vegetable marrows were found superior to the ordinary summer squashes of the seedsmen. The Cocozella of Geneva was one of the best. Nos. 4365 and 4366, the latest plantings, produced five to ten fruits per vine, size 3 to 4 inches in diameter and 18 inches long. They were good keepers when ripe; piled under a tree in the field, they kept perfectly for a year. The quality as a winter squash was not equal to Hubbard, nor as a summer squash were these varieties considered superior to Fordhook.

Vicias.—None of the vicias so successful elsewhere have as yet done well at this substation. *Vicia monantha*, the one-flowered lentil of France, a noted forage annual, planted on the sandy soil of the home tract, grew only 6 inches high. *V. fulgens* (No. 1514), *V. sativa* (No. 1507), and *V. narbonensis* (No. 1509) were no better. None of them made seed. On the ten-acre tract, the vetches suffered from alkali. They can be expected to do better in the foothills surrounding Chino Valley.

Watermelons and Stock-melons.—No. 4269, "Mathis, from South Carolina," was planted on the home tract early in May, 1901. It was an

excellent melon, but the vines did not grow as well as the old Mountain Sweet. The best stock-melon ever tested at the substation, and one well worth wide distribution, is the Tsama or Khama melon (see Plate 11), a native of the Kalahari desert in South Africa. This seed was sent out several years ago by the Division of Botany at Washington. It did but poorly at first, but now, after three years of further trial, it is evident that it yields about twice as much to the acre as does the Kansas stock-

PLATE 10. KANSAS STOCK-MELON.

PLATE 11. TSAMA OR KHAMA MELON.

melon, and stands drought better. The illustrations show comparative yields of two hills grown under similar conditions, on poor, sandy, unirrigated soil. The rainfall was 17 inches; but the melon has done quite as well with only 9 inches, and seems as drought-enduring as the wild gourds and cacti which thrive with an annual rainfall of only 4 or 5 inches. The melons are small, round, covered with small prickles, and are not attractive, but stock eat them readily, especially when somewhat wilted. They keep extremely well. Seed of this stock-melon has been widely distributed by the University for two seasons past, and the seedsmen are beginning to grow and advertise it.

SANTA MONICA FORESTRY SUBSTATION.

(Near the mouth of Santa Monica Cañon, two miles west of Santa Monica.)

This forestry substation was established in the winter of 1887–8 by the State Board of Forestry, and was transferred by the State to the University of California, July 1, 1893. The forestry plantation of 29 acres near Chico came under the control of the University in the same way. The State Board of Forestry was abolished by the same Act which made the transfer.

For the first two years the sum of $2,000 per annum was granted by the State for forestry purposes, and this was raised to $2,500 per annum in 1895–6, but all direct State aid ceased at the close of 1896–7, since which time the University has made small annual appropriations, at no time equal to those formerly made by the State. The progress of the substation has therefore been slow, as lack of means prevents many needed improvements. The policy has been to spend the larger share of the appropriation at Santa Monica, and to keep a foreman there.

While the Santa Monica substation is in some respects the most attractive of all the substations, as it possesses a practically frostless climate, it is better suited for a botanical garden than for pure forestry, for which, indeed, the area is too limited. It affords an excellent location for tests, on a small scale, of acacias, eucalypts, pines, and a few other classes of trees, and now that the water-supply is ample, its unique value, possessed by few places in the United States, lies in the direction of a botanic garden, in which a great variety of plants from all parts of the world could be grown.

Changes and Improvements.—The substation has had four foremen since 1893—Mr. W. J. Strachan, Mr. John H. Barber, Mr. Charles A. Colmore, and Mr. William Shutt. The latter took charge on September 1, 1900. Mr. Roy Jones, son of Senator J. P. Jones of Nevada, continues to serve as Patron.

The most important improvement since the issuance of the report of 1897–8 consists of an unexpected development of the water-supply, made by Mr. Shutt, as foreman, in the winter of 1900–1901. The daily flow from the new springs, cut by drifting farther into the bank, is about 16,000 gallons, and this enables more land to be irrigated on the lower flat. The hydraulic ram is again used to lift water to the house, and the windmill is no longer needed, except when repairs are being made to the other systems.

Some desirable changes in the roads and grades have been lately made, and about three acres of brush-covered land has been cleared. A good deal of this has been planted with acacias and eucalypts. This is excellent soil, although so steep as to be unfit for anything but trees.

CLIMATE.

The climate of Santa Monica and its vicinity is justly famous for its evenness, and a very great variety of native and exotic plant life is found here, as at Ventura and Santa Barbara. Thorough cultivation is absolutely necessary, however, with the light rainfall, and irrigation is practiced wherever possible. The forest trees grown at the substation, however, have received no irrigation excepting as noted in the following pages. Small trees, when first set out from the nursery, often require a little water. As a rule, this "irrigation" consists of a quart or two of water given to each tree from a barrel on a sled. A hole is made beside the tree and the water poured slowly in. When it settles, the hole is filled up with dry earth. One such watering in April has enabled eucalypts and acacias to take root and grow well thereafter; without it, losses would probably amount to half the stock.

Rainfall.—Since the University took charge of the place, the annual rainfall has been as follows:

Year.	Rainfall.	Comment.
1893–4	7.83 in.	An extremely trying year.
1894–5	14.01 "	Fairly good crops.
1895–6	8.40 "	North winds; crop poor.
1896–7	16.13 "	An excellent year.
1897–8	5.24 "	Crops failed; some large trees died.
1898–9	7.11 "	Crops scanty; some trees died.
1899–1900	8.48 "	Crops scanty; some trees died.
1900–1901	11.54 "	Fairly good crops.
1901–1902	11.65 "	Good crops.

The average rainfall for the above nine years has therefore been a trifle over 10 inches. It would seem to persons unacquainted with California conditions as if this low rainfall would make tree-growth impossible, but the statistics elsewhere given show plainly that such is not the case. In fact, one especial value of this substation is its trial, for a long term of years, of a great number of species of trees under an average rainfall of 10 inches.

The monthly rainfall varies greatly from season to season, as shown by the following table of the precipitation during the past four seasons:

Month.	1898–99.	1899–1900.	1900–01.	1901–02.
October	0.34	1.11	0.25	2.41
November	none	1.25	5.66	none
December	.10	1.59	none	none
January	4.56	2.45	none	1.75
February	.01	none	4.35	3.90
March	1.69	.55	.20	3.27
April	.05	.17	.50	none
May	none	.36	.58	none
June	.36	none	none	none

In practice, a rainfall of less than half an inch in any given month is of little value. The desirable thing is to have "enough rain to start plows" in November or December; then to have heavier rains in January or February, followed by spring showers. The favorable distribution of the rainfall doubles its usefulness. This year (1902, May 1st) some barley on the upper mesa stands 3½ feet high and cuts 4 tons of hay to the acre. Young eucalyptus trees, also on the upper mesa, have made from 3 to 6 feet of growth this season. The above table,

however, shows that trees and hay received 2.71 inches of rain before January, and after January nearly 9 inches, all well distributed. The crops are better than in 1894–5, with 14 inches badly distributed through the winter.

Temperature.—Only once during the nine years has the frost injured heliotropes, nasturtiums, cannas, and other tender garden plants in this district, but not then on the middle mesa of the substation, where no serious injury has ever been done to even the most tender eucalypts. The lowest flat, by the creek, has proved too cold and shady for *Ficus elastica* and many other plants. On the middle mesa, where the most valuable plantations exist, the immunity from frost is exceptional. Here are growing Hibiscuses, Bauhinias, the Jacaranda mimosæfolia, Tacsonia manicata, Eucalyptus ficifolia, and many other tender plants. The following table, continuing the record in the annual report for 1897–8, gives the temperature at the substation from June 30, 1898, to April 1, 1902:

MONTHLY SUMMARY OF TEMPERATURE.

	Max.	Min.	Mean Max.	Mean Min.	Mean Temp.
1898—July	79°	52°	74°	57°	65°
August	84	54	78	58	68
September	98	50	76	56	66
October	79	42	71	49	60
November	82	42	69	47	58
December	88	41	68	47	57
1899—January	77	38	66	45	55
February	77	33	59	41	50
March	89	37	64	48	56
April	89	42	66	47	54
May	77	43	66	49	57
June	82	48	68	55	61
July	83	49	73	55	64
August	86	51	73	55	64
September	80	51	73	56	64
October	99	42	71	51	61
November	83	42	69	51	60
December	77	41	66	46	56
1900—January	78	42	67	45	56
February	86	42	69	46	57
March	83	40	66	49	57
April	77	39	65	46	55
May	73	44	66	47	56
June	76	50	62	70	55
July	95	51	65	75	58
August	96	52	68	77	60
September	96	48	63	70	56
October	86	46	68	50	63
November	92	47	73	54	64
December	86	39	64	47	57
1901—January	71	37	60	43	52
February	87	33	64	48	56
March	87	39	68	48	58
April	71	38	62	47	54
May	66	43	64	50	57
June	80	44	66	55	59
July	81	50	71	55	63
August	84	48	73	56	65
September	82	44	69	51	60
October	92	62	65	52	60
November	82	43	66	47	57
December	80	33	66	43	55
1902—January	82	33	62	42	52
February	69	35	59	42	50
March	73	35	63	42	53

In January, 1898, the thermometer fell to 31°, but 33° is the next lowest winter minimum, and the average minimum of nine years was

35°. The maximum has in nine years but once reached 100°, but every year has gone to 90° or above for a few days. The maximum of 1898 was 98°, and the next highest temperatures of that year were 93° and 89°; in 1899 the two highest temperatures were 99° and 89°; in 1900 they were 95° and 92°, and in 1901 they were 92° and 87°.

THE EUCALYPTUS GROVES.

The plantations of eucalyptus trees at this substation have deservedly attracted much attention for some years past. They have been visited by many persons and reported upon in many forms. Mr. Abbot Kinney's work on Eucalypts contains photographs of single trees here, together with notes upon their growth, etc. Professor McClatchie has also taken many notes and photographs here. Former station reports contain much historical and descriptive material on these eucalypts. (See Report of 1892–4, pp. 428–432; Report of 1894–5, pp. 450–455; Report of 1895–7, pp. 412–426; and Report of 1897–8, pp. 340–351.)

A few of the large trees in the main group have died or have been blown down. These losses seem to have been due in every case to poor root systems, pot-bound or too large trees having been originally used. The younger plantations show no such defects. Others of the older trees will soon have to be removed, but specimens of all the species represented in this grove are now established elsewhere.

The following table shows some of the measurements taken in this, the oldest grove of eucalypts in June, 1902:

	Height.	Girth.
E. amygdalina	23 ft.	21 in.
E. calophylla	38 "	47 "
E. citriodora	61 "	35 "
E. corymbosa	36 "	32 "
E. corynocalyx	61 "	47 "
E. diversicolor	68 "	42 "
E. viminalis	53 "	44 "
E. callosa	32 "	15 "
E. sideroxylon	53 "	52 "

Eucalypts on the Upper Mesa.—The original planting of eucalypts, done on the upper mesa nearly one hundred feet above the middle flat, was in the form of a narrow strip, chiefly on the western side, with a few rows across the south and north. This mesa is a long and very narrow tongue of land nearly level on the top, sloping south toward the ocean. On the east it descends almost perpendicularly to the cañon bottom; on the west the descent, less abrupt, is to the cottage mesa, or middle bench of the substation. The light, gravelly soil, and the height and exposure of this plateau, make the growth of trees difficult. Success here argues similar success on plateaus even farther inland.

The eucalypts planted here in 1889, thinned out in 1893 and 1894, and since then uncultivated, have made in many cases noble trees, with trunks that girth from 25 to 40 inches. Their growth has been lessened in recent years by light rainfall, as most of them stand within sixty feet of the edge of the mesa. In point of drought-resistance *E. corynocalyx*, *E. rostrata*, *E. paniculata*, and *E. globulus* are among the best.

The younger grove on the upper mesa was begun in the spring of 1897, when about eight hundred trees were set out, representing thirty-one species. Other trees have been added since. The soil is light and poor,

PLATE 12. EUCALYPTUS GROVE, THREE YEARS OLD—SANTA MONICA FORESTRY SUBSTATION.

especially toward the eastern end, and the older trees near by have lessened the growth of the outer row of the new plantation. Nevertheless, the results of the experiment have been instructive, and on the whole favorable.

The well-known blue gum, *E. globulus*, made much the strongest growth in this plantation, and most of the trees had to be cut out so as to give the more valuable species a chance.

The following table shows the comparative growth of the more promising species in this new plantation. All the trees were small, or from 10 to 15 inches high, when planted out in January, 1897. All were measured in May, 1902, when the age from seed was less than six years. This May measurement includes of course only a part of the 1902 growth. The trees selected are an average of the western half of the grove, which much better represents the entire mesa than the more gravelly eastern end.

EUCALYPTS IN MAY, 1902.

	Height.	Girth.
E. globulus	32 ft.	23 in.
E. acervula	30 "	22 "
E. muelleriana	28 "	20 "
E. rostrata	27 "	20 "
E. angulosa	25 "	18 "
E. andreana	25 "	17 "
E. tereticornis	23 "	19 "
E. goniocalyx	23 "	17 "
E. populifolia	22 "	15 "
E. cosmophylla	21 "	16 "
E. Foeld-Bay	21 "	14 "
E. stuartiana	20 "	16 "
E. cinerea	20 "	15 "
E. acmenoides	20 "	10 "
E. paniculata	18½ "	13 "
E. resinifera	18½ "	13 "
E. microcorys	18½ "	12 "
E. dicipiens	16 "	12 "
E. polyanthema	16 "	10 "
E. botryoides	14 "	11 "
E. jugalis	13 "	10 "
E. sideroxylon	9 "	9 "

This table is very suggestive. In 1898, *E. goniocalyx* had made a better showing than the blue gums, but it now ranks eighth. Every species in this list which stands over 15 feet high at present (nineteen species in all) is well worth further trial and planting on a larger scale, for the average annual rainfall since these trees were set has been but 8.8 inches, and for the first three years it was less than 7 inches. The only water ever received by any of these trees was about a quart each when planted, that being a very dry year. In ordinary seasons, that is, in seasons of ten or more inches of rainfall, even this slight irrigation would not have been needed.

The growth of *E. acervula*, *E. muelleriana*, *E. rostrata*, and a few others, as shown by the table, is especially striking. All the species listed in this table have made well-shaped trees. *E. cornuta*, *E. megacarpa*, *E. alpina*, and a few others of shrubby growth have only a botanic value here, but among those which have made strong growth are some extremely valuable timber trees, such as *E. rostrata* and *E. muelleriana*.

Enlargement of Collection.—When the University took charge of the substation in 1893, there were forty-four species of eucalypts growing here, as nearly as could be determined by the Botany Department.

Many of these were represented by only one or two specimens. At the present time there are something more than a hundred species here, many of them represented by fifty or more specimens of different ages and on different soils. All of these new species have been grown from

PLATE 13. E. SIDEROXYLON (VAR. ROSEA).

seed obtained from various botanical gardens, from Vilmorin & Co., Paris, or from the Department of Agriculture at Washington.

Among the newer sorts are a number of hybrids, which prove most interesting in their rapid growth and their promise of future value to

California. It is evident that crosses of the best eucalypts are likely to produce valuable results, giving possibly (*a*) finer and more free blossoming, and hence greater value for ornament and as honey-yielders; (*b*) better growth, more hardiness, or other economic advantages.

Among all the newer species, however, none are more striking in appearance than *E. ficifolia*, by far the most brilliant, medium-sized tree of the family. In some respects even more graceful and ornamental is the famous *E. sideroxylon* var. *rosea*, a superb, quite hardy, drought-resisting species of much larger growth than *E. ficifolia*. Its dark, red-brown bark, bluish foliage, and elegant, half-weeping branches, give it a distinguished appearance in any collection, and the largest specimen at the substation, a plate of which, made in 1896, is herewith shown, has increased in size steadily since that date. Younger trees make good growth and bloom early. There is no more promising species for general ornamental planting in southern California. *E. calophylla*, which has been widely planted, is a very showy species, but if *E. sideroxylon* var. *rosea* were more generally known it would probably take the lead.

The following periods of the eucalypts range over the entire year, and those who plant collections of these valuable trees never need be without blossoms. The following notes apply not only to Santa Monica, but also to the whole seacoast region south of Santa Barbara:

Months.	Species Usually Blooming.
January and February	Amygdalina, globulus, leucoxylon, occidentalis, polyanthema, robusta.
March and April	Amygdalina, diversicolor, eugenoides, leucoxylon var. rosea, marginata, meliodora, obliqua.
May and June	Citriodora, corynocalyx, diversicolor, eugenoides, gunni, obliqua, paniculata, rostrata, stuartiana.
July and August	Buprestium, calophylla, ficifolia, corynocalyx, "Sewell's Red," macrorhynchus, etc.
September and October	Alpina, calophylla, ficifolia, corymbosa, cornuta, lehmanni, etc.
November and December	Alpina, corymbosa, diversicolor, globulus, occidentalis, robusta, polyanthema, saligna, etc.

The New Grove of 1901.—There were some three hundred trees planted in January, 1901, at the northern end of the middle mesa. Their growth has been excellent, as shown by the following table. In a few cases measurements were again taken in May, 1902, to show the excellent spring growth, and these notes follow the table. These trees have received no irrigation since planting. Those from Department of Agriculture seed are indicated by the numbers in the second column of figures:

Name.	U. C. No.	Govt. No.	Size When Planted.	Size in Jan., 1902. Height.	Size in Jan., 1902. Girth.
E. incrassata	121	1652	15 in.	10 ft.	7 in.
E. rudis × rostrata	128	1672	16 "	8 "	8 "
E. botryoides × rostrata	130	1678	15 "	5 "	5 "
E. rostrata × resinifera	127	1670	18 "	8 "	8 "
E. maculata	119	1646	10 "	8 "	7 "
E. sp.	115	1635	16 "	6 "	5 "
E. stellulata	120	1651	8 "	6 "	7 "
E. longiflorus	105	1609	10 "	4 "	10½ "
E. pilularis	---	1657	8 "	5 "	7 "
E. macrocarpa	118	1644	12 "	6 "	5 "
E. raveretiana	125	1663	10 "	7 "	8 "
E. obtusiflora	122	1654	10 "	5 "	5 "
E. sp.	114	1633	12 "	6 "	5 "
E. pauciflora	108	1617	8 "	2 "	1½ "
E. macrandra	117	1643	8 "	1 "	½ "
E. sp.	116	1639	8 "	6 "	3 "
E. eximia	160	1625	8 "	6 "	3½ "

Name.	U. C. No.	Govt. No.	Size When Planted.	Size in Jan., 1902. Height.	Girth.
E. punctata var.	164	----	12 in.	9 ft.	8 in.
E. salmonophloia	168	----	8 "	3 "	2½ "
E. sieberiana	170	1675	8 "	8 "	5 "
E. stricta	171	----	8 "	3 "	4 "
E. McArthurii	161	----	12 "	10½ "	8 "
E. robusta	---	1668	18 "	7 "	6 "
E. corynocalyx	---	1620	15 "	9 "	7 "
E. rubida	167	----	12 "	11 "	7½ "
E. stuartiana	36	1676	16 "	12½ "	8 "
E. pulverulenta	163	----	8 "	8 "	5 "
E. globulus	---	----	15 "	13 "	9 "
E. rostrata	20	----	15 "	9½ "	7 "
E. resinifera var. grandiflora	27	----	18 "	10 "	6 "
E. sideroxylon	9	----	18 "	7 "	5 "
E. tereticornis	29	----	12 "	8 "	5 "
E. redunca	165	----	6 "	12 "	½ "
E. obcordata	162	----	6 "	2 "	3 "

Notes on Eucalypts from the Department of Agriculture.—No. 1652, *E. incrassata*, the "Mallee" gum, increased 2 feet in height between January and May, 1902. This species stands up fairly well against the wind, but some specimens are crooked and poor.

No. 1672, *E. rudis* × *E. rostrata*, is more stocky than the preceding and promises good results. The permanent leaves show considerable variation in different plants, as if the type were not yet fixed.

No. 1678, *E. botryoides* × *E. rostrata*, known in France as *E. Trabuti*, is a very interesting tree. While slower in growth than many species, it is now gaining (growth from January to May, 1902, was 3 feet). The trees are remarkably uniform in appearance and incline to spread.

No. 1670, *E. rostrata* × *E. resinifera*, has also shown rapid spring growth, average plants girthing 1 inch more in May than in January and standing 2 feet higher. The *rostrata* blood shows very plainly in this cross. It is worthy of extended trials.

No. 1646, *E. maculata*, the "Morrel Gum"; No. 1617, *E. pauciflora*, the "White Gum"; No. 1616, *E. globulus*, the well-known "Blue Gum"; No. 1622, *E. crebra*, the "White Ironbark," and some others are already represented by large trees, as well as in the new plantations. The best young specimen of *E. globulus* measured May 1st was 17 feet high and girthed 12 inches.

No. 1635, received as "a species," is otherwise noted in the Inventory as *E. gracilipes*, which is said to resemble *E. leucoxylon*. It is a slow grower here, and does not as yet seem superior to *leucoxylon*.

No. 1633, also unnamed when received, is *E. gomphocornuta*. Its growth is practically identical with that of No. 1643 (*E. macrantha*), which is extremely poor. It evidently requires more rainfall and a heavier soil.

No. 1639, which came unnamed, but was inventoried as *E. jugalis*, a "small tree 25 to 30 feet high," is a very beautiful species, much resembling in tint, odor, and appearance a half-dwarf *E. globulus*. The plant is more graceful, and the first leaves somewhat more pointed. Its growth averages 6 feet, as against 15 feet for *E. globulus*. This species should have value for ornamental planting.

No. 1609, *E. largiflorens*, the "bastard box," a valuable timber tree, grows very slowly compared with other species. *E. pilularis*, the Blackbutt (No. 1657), does somewhat better, and *E. stellulata*, the "Green Gum" (No. 1651), exceeds by a trifle such species as *E. macrocarpa* and

E. eximia of the same age and under similar conditions. *E. raveretiana*, the "Gray Gum" (No. 1663), is considerably better in point of growth than any of these.

One of the most striking of the new eucalypts is *E. stuartiana* (No. 1676), also received from other sources. Trees of this, on May 1st, were 14 feet high and girthed 11 inches. *E. corynocalyx*, the noted "Sugar Gum" (No. 1620), grew 3 feet between January and May, and is also one of the best in appearance among the species in this plantation.

Other New Eucalypts.—Several species or sub-species, not heretofore named, have done very well. One of the very best of these is *E. punctata* var. *grandiflora*, of excellent upright and rapid growth. *E. resinifera* var. *grandiflora* is another of striking appearance. Both the above have made trees 12 feet high in fifteen months after planting out, and both, like *E. rostrata* and *E. corynocalyx*, are worth the serious consideration of planters. *E. rubida* has done nearly as well, and is also a desirable species. *E. McArthurii* yields badly to the sea winds. *E. stricta* has grown slowly and very poorly. *E. obcordata*, while very slow in growth, is a handsome shrub.

Distributions of Seed and Trees.—Eucalyptus seeds gathered at this substation were to some extent distributed locally. Trees of new and rare species to the number of 4,000 were distributed to such applicants as agree to make future reports. Among those receiving trees were the American Beet Sugar Company at Oxnard, the Hollywood Cemetery Association, the Imperial Land Company, Senator Thomas R. Bard, Mr. T. P. Lukens, Mr. Theodore Payne, and Mr. W. L. Clayberg. These trees were sent to widely scattered points, from Indio and Imperial to Santa Barbara and Antelope Valley. Many small lots of a dozen named trees were sent out. The number of species distributed was twenty-five, including *E. ficifolia* and other ornamental sorts, *E. corymbosa*, *E. polyanthema*, and other honey eucalypts, and *E. corynocalyx*, *E. rostrata*, and other timber and drought-resisting species.

Hillside Planting.—In 1901 and 1902 a number of eucalypts were planted on the newly-cleared hillslopes. In places these were too steep to plow and the trees were "pocketed in." The results have been very satisfactory, not one out of four hundred trees having been lost. Most of the species represented in the new plantation on the middle mesa were used here also, together with a few represented only on the upper mesa. In all, nearly thirty species were set on this slope. On similar slopes, pines (*P. insignis* and *P. austriaca*) and six species of acacias were planted at the same time and have made a good start. Each of these trees received a quart of water when planted out.

ACACIAS.

In previous reports attention has been called to the value of the tanbark acacias for otherwise waste lands wherever the winter temperature does not fall below 22° Fahr. A full account of the yield of eight-year-old trees of *Acacia decurrens*, *A. mollissima*, and *A. pycnantha*, together with analyses, appears on pages 227–230 of the Report for 1897–8. The remaining portion of the acacia grove therein reported upon suffered much from drought in 1898–1900, but the past two winters

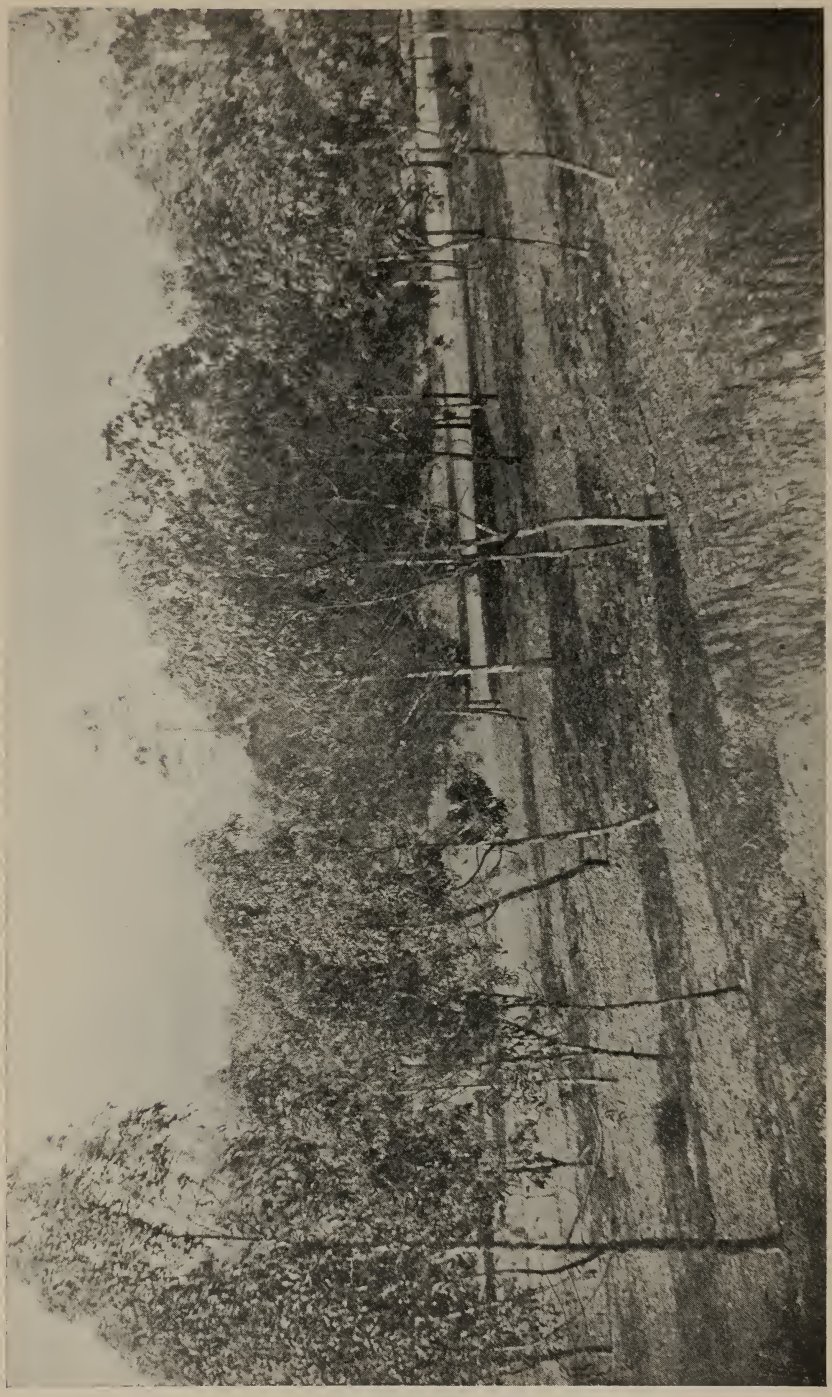


PLATE 14. ACACIA GROVE (*A. pycnantha* AND *decurrens*)—SANTA MONICA FORESTRY SUBSTATION.

have greatly aided it. Young trees planted out in the winter of 1901 and the present season have also done very well indeed.

Drought-Resistance.—All observations at the substation confirm the view that on the light, gravelly wash of the mesa, the large tanbark acacias stand the drought somewhat better than do the eucalypts. Seedling trees also frequently spring up in the grove. With good cultivation, a grove of *A. decurrens* or *A. mollissima* can be established in such soil without any irrigation and with an annual rainfall of only 10 inches.

The largest specimen of *A. decurrens*, now twelve years old, girths 3 feet 9 inches, measured breast-high; this surpasses both *A. mollissima* (largest tree, 2 feet 10 inches) and *A. dealbata* (largest tree, 2 feet 4 inches). *A. cyanophylla*, a low, shrub-like, much-branched tree, quite unlike the two preceding species, which rise to 40 and 50 feet, has in the case of the largest specimen a trunk girthing 3 feet 1 inch. All these stand on soil similar to that of the older eucalypts and have suffered less in times of drought.

Acacia melanoxylon, whose beautiful rosewood-like timber only needs to be better known to be demanded among cabinet-makers, has now, in 1902, fully recovered from its severe suffering in the years of drought, when one half of the large trees of this species ceased growth and some died. This recovery when the annual rainfall rose from about 6 inches to nearly 12 inches is interesting, but the profitable growth of this riverine species for timber is evidently limited to regions of more rainfall and better soil. Nevertheless, the largest standing tree of *A. melanoxylon*, aged twelve years, girths 3 feet 8 inches.

The rapidity of growth of *A. melanoxylon* is hardly surpassed by any other species, and it reproduces itself freely from root-cuttings or suckers as well as from seeds. One large tree removed in 1899, because it died in the ground, threw up a multitude of suckers scattered over a large area. Nine of these have been left at spaces of from 10 to 20 feet apart; they average a height of 18 feet and a girth of 15 inches. Fed, of course, by the old roots, this growth far surpasses that from seeds. In suitable locations, however, a wood-lot of *A. melanoxylon* could be trusted to reproduce itself from the roots. The fuel value of the wood is high.

Other Acacias.—A new collection of acacias was planted out in the spring of 1901, and with previous plantings and a few set in the spring of 1902, the total representation of acacias is now nearly thirty species. One of the most striking of these is *A. Baileyana*, a very ornamental tree. *A. verticillata* and *A. linifolia*, both species of small growth, have attracted much attention.

OAKS AND OTHER HARDWOOD TREES.

English Oak (*Quercus robur*).—The English oak has now received a thorough test here on all the levels. Many trees promised well until about 1897. The largest, twelve years planted, now girth from 14 inches to 21 inches, a foot from the ground, and this would be excellent if the trees were healthy. But four out of five of the trees this age are dead or dying at the top. A few are 16 feet high; the tallest healthy tree is but 13 feet. The growth is seriously affected, as elsewhere on the coast,

by the little "oak wasp" (*Andricus* sp.), and the whole tendency of the tree is to grow shrubby and crooked. It has taken much pruning and suckering to keep them in shape. The tree is therefore practically useless here for timber purposes, as are all the oaks tested at this substation.

The Japanese species need better soil and more water; the Eastern oaks grow very slowly indeed. In the cañon the native coast live oak (*Quercus agrifolia*) grows very well, and there are some good trees of this species on the substation tract. Its growth is checked by caterpillars.

Black Locust.—This well-known tree remains the leading small hardwood adapted to this climate. It thrives on the middle mesa without irrigation, and reproduces readily from self-sown seed. Few trees have stood the severe droughts better. Trees can be grown here with trunks of 8 or 10 inches in diameter in twelve years. This tree in recent years has been much neglected; its value for fuel and fence-posts, as well as for various hardwood uses, justifies more general planting.

The Casuarinas.—No species of hardwood trees have proved more drought-resistant here than the larger casuarinas. *C. suberosa* is one of the best. *C. glauca* has done well. The largest trees of *C. suberosa*, now twelve years old, show trunks 6 feet to lowest branches and girthing from 2 feet 2 inches to 2 feet 10 inches. Such growth gives evidence of the great value of casuarinas to tree-planters.

Zelkova keaki.—This Japanese hardwood tree needs more rain; otherwise, the climate is well adapted to its growth. It develops, however, too slowly in California to be of value anywhere when compared with other species of hardwoods.

Ashes.—After long trial of five species, including the European White, American White, etc., the Arizona ash (*Fraxinus velutina*) proves by far the best for this locality. So well does it grow from seed that a plantation, if rainfall or irrigation up to an average of 15 inches per annum can be obtained, should be profitable. Here, with an average of only 10 inches, the tree, though making a good start, does not equal the common black locust, the casuarina or the best acacias; but it is exceedingly drought-resistant.

Maytenus boaria.—This little Chilian hardwood tree has taken hold remarkably here, growing fast without irrigation. Its value for ornamental purposes is undoubted, but its hardwood value depends on rate of growth, which is greater here than at Berkeley, with greater rainfall.

Other Hardwood Trees.—There are many interesting and valuable trees in the arboretum here which have proven their adaptation to the locality, and some of these deserve especial mention.

Seed of the *Schinus terebinthifolius*, a new and large-leaved pepper tree, was locally distributed last season. The demand is great and increasing. It is a much more bright-leaved, healthy, and attractive tree than the common pepper tree (*Schinus molle*), and should in great degree supersede it. As in the case of the common species, the berries are red and handsome; the leaves and general growth are superior. It was planted on a dry hillside and has received no irrigation.

CHICO FORESTRY SUBSTATION.

(Situated one mile east of Chico, near the Sierra foothills; elevation, 230 feet.)

In previous reports the history of this substation has been given, and need not be repeated. Three years' further experience with the location only makes more evident its great value as regards soil, climate, and facilities for the cheap and rapid production of fine forest trees, or for any agricultural experiments.

Five acres as yet unplanted remain at the western end of the tract, and the soil there is extremely rich. The vacant land at the upper or eastern end of the tract is more sandy, though still excellent for tree growth.

Since 1898 the substation has been carried on at a reduced expense, using the Rancho Chico teams and labor and paying merely the actual cost. A workman has occupied the small house on the grounds and has kept the place in order, working elsewhere when not needed at the substation. In 1901, Mr. T. L. Bohlender, formerly in charge of the Chico nursery and later the ranch foreman, made an agreement by which he gives a portion of his time to supervision of the work at the substation, and this arrangement continues.

The substation, however, needs the entire time of some competent person, as at Santa Monica, or it might with advantage be developed hereafter into a substation fully equal in importance to that near Pomona, for not less than five acres of its area can be devoted to agricultural experiments without seriously infringing upon its forestal value. Besides, it is probable that a larger area can be secured when needed for strictly forestry work. At all events, the foundation for a most useful Sacramento Valley substation exists at Chico, where also sufficient trees can be easily and cheaply grown to cover the entire eastern or hill portion of the University tract at Berkeley.

There have been no other changes in local management. Mr. V. C. Richards, editor of the Chico "Record," appointed Patron in 1897, still holds that office. Colonel C. C. Royce, manager of Rancho Chico, and Mrs. Bidwell, the owner of that famous place, have continued their interest in the station.

Eucalyptus Planting.—The most important extension planned for is that of the eucalypts at the eastern end of the tract. About four thousand trees of *E. rostrata* and other hardy species are being grown for planting here in the autumn of 1902. They are now in seed-boxes and will be set out with the first rains.

CLIMATIC CONDITIONS.

There is very little difference in climate between the town of Chico and the substation. Some seasons the cold is less at the latter place, but severe frosts are about the same everywhere along the creek. In

fact, some of the orchards which have suffered most are several miles east of Chico, and at a considerable elevation. Only a few species of acacias do well here, and the eucalypts are also limited in their adaptation to this region. The growth of the conifers is enormous, and that of many oaks and ashes is also unusually great. The rainfall is excellent; the summer heats are modified by the trade winds.

Rainfall.—The average rainfall of the Chico district, based on observations since 1870, is somewhat over 25 inches. It has fallen as low as 12 inches, and has risen to more than 50 inches, but these extremes very rarely occur. The following table shows the rainfall for the past seventeen years, the average of which, disregarding 1901–2, which is not quite complete at this date, is 26.64 inches:

RAINFALL FROM SEPTEMBER, 1885, TO APRIL, 1902.

Season.	Total Rainfall.	Period in which Some Rain Fell.
1885–6	31.13 in.	7 months 12 days.
1886–7	17.16 "	7 " 28 "
1887–8	14.49 "	7 " 12 "
1888–9	21.50 "	9 " 11 "
1889–90	52.71 "	7 " 5 "
1890–1	23.46 "	9 " 10 "
1891–2	22.40 "	7 " 12 "
1892–3	33.50 "	7 " 10 "
1893–4	23.32 "	10 " 4 "
1894–5	34.56 "	7 " 28 "
1895–6	25.54 "	7 " 1 "
1896–7	22.44 "	9 " 20 "
1897–8	12.81 "	7 " 2 "
1898–9	18.45 "	6 " 5 "
1899–1900	24.89 "	7 " 1 "
1900–1	27.22 "	7 " 22 "
1901–2	19.96 "	7 " 22 "

There is a good deal of early summer rain in this region, lengthening the season. The rains have commenced as early as August 30th, but the usual time is in late September or early October. They have continued until July 11th, in showers after April, excellent for many crops, but injuring cherries, hay, etc. The rainless period is comparatively short here, and the growth of all kinds of trees suitable to the climate is therefore stimulated. No other portion of California with which I am acquainted has shown such rapid growth of the native white oak (*Quercus lobata*), nor such large groves of second-growth trees springing up since the American occupation, and this must be attributed in great measure to the favorable rainfall.

Temperature.—The observations of the past twenty years give an average winter temperature of 46.6° Fahr., an average summer temperature of 81.3°, and an average annual temperature of 63.8°. The lowest temperature of the period was 18°, and the highest was 115°.

The following table shows the temperature day by day during 1899, 1900, and 1901, as furnished by Colonel C. C. Royce, and kept on Rancho Chico. These temperatures were taken from a point fifteen feet above the ground, and the minimums therefore show from 5° to 8° lower than would be the case if taken in the town, on the plan of the Weather Bureau, from the top of a high building. They were taken for agricultural purposes, and show the actual conditions to which vegetation at the forestry station and the adjacent district is subjected:

TEMPERATURE RECORDS AT RANCHO CHICO.

	1899.	1900.	1901.
January.			
Temperature—			
Mean for month (Fahr.)	53°	48°	44.9°
Warmest day	27th 75	6th, 17th 62	16th 62
Coldest day	4th 29.5	24th 30	1st 23
Range	45.5	32	39
Greatest daily variation	24th 31	9th 23	19th 29
Least daily variation	18th 5	28th 3	2d 6
Mean daily range	17.5	11.4	17.2
Mean lowest	46	42	36
Mean highest	59	54	53.9
Frost on	8th, 12th, 23d, 24th.	9th, 10th, 11th, 25th.	7th, 15th, 16th, 23d–26th, 28th.
Rain on	6th, 7th, 9th–11th, 13th–15th.	1st–5th, 12th–15th, 18th, 28th.	3d, 4th, 6th, 8th, 10th–14th, 20th, 21st, 24th, 31st.
Fog on	17th, 18th.	12th–15th, 18th–22d, 29th–31st.	13th, 14th, 29th, 30th.
Ice on		24th.	1st, 9th, 10th, 17th, 19th, 29th.
February.			
Temperature—			
Mean for month	51	50.3	48.5
Warmest day	19th 79	24th 70	28th 77
Coldest day	6th 24	7th, 9th 33	10th 26
Range	55	37	51
Greatest daily variation	18th 31	23d 31	10th 32
Least daily variation	28th 7	7th 2	5th, 13th 8
Mean daily range	23.7	19.3	18.9
Mean lowest	39.1	39.8	39.1
Mean highest	63	60.7	58
Frost on	10th, 11th, 25th.	5th–7th, 9th, 11th, 12th, 23d, 27th, 28th.	
Rain on	28th.	1st, 2d, 17th–20th, 25th.	2d–5th, 7th, 13th, 16th, 18th–20th.
Fog on		2d, 3d.	
Ice on	4th, 5th, 6th.	Hailstorm, 18th.	1st, 6th, 10th, 11th. Snow on 7th, 8th.
March.			
Temperature—			
Mean for month	53.8	57.3	54.9
Warmest day	6th 74	13th 81	5th 78
Coldest day	10th 30	28th 33	31st 34
Range	44	48	44
Greatest daily variation	6th 35	28th 36	19th 33
Least daily variation	15th 3	7th 4	4th 3
Mean daily range	20.4	23.4	23.4
Mean lowest	43.6	45.5	42.2
Mean highest	64	69.1	67.5
Frost on	10th, 13th, 30th.	28th.	8th, 13th–15th, 28th–31st.
Rain on	7th, 8th, 12th, 14th, 15th, 17th, 19th–20th, 22d–24th, 31st.	3d, 4th, 6th–8th, 19th.	9th, 10th, 22d, 25th, 27th, 28th.
Ice on	13th.	Hail, 4th.	
April.			
Temperature—			
Mean for month	59.9	57.3	55.9
Warmest day	21st 87	17th, 18th 81	13th 81
Coldest day	29th 36	9th 35	4th 30
Range	51	46	51
Greatest daily variation	29th 39	17th 36	10th 40
Least daily variation	23d 14	11th 3	5th 3
Mean daily range	28.2	23.7	25.2
Mean lowest	45.8	45.2	41.7
Mean highest	74	69.3	70.1

TEMPERATURE RECORDS AT RANCHO CHICO—*Continued.*

	1899.	1900.	1901.
April—Continued.			
Frost on	24th, 25th, 28th, 29th.	9th.	3d, 4th, 6th–10th, 22d.
Rain on	24th, 30th.	1st, 2d, 6th, 11th, 12th, 19th–21st, 30th.	2d, 5th, 28th, 29th.
May.			
Temperature—			
Mean for month	62°	64.8°	63.7°
Warmest day	10th 96	31st 92	31st 92
Coldest day	1st 38	11th, 27th 44	19th 41
Range	58	48	51
Greatest daily variation	12th 39	20th, 30th 26	8th 38
Least daily variation	31st 14	4th 16	24th 13
Mean daily range	27.5	28.3	27.2
Mean lowest	47.9	51.8	50
Mean highest	75	77.7	77.4
Frost on	1st, 2d, 15th.		
Rain on	23d–25th, 28th, 31st.	1st, 3d–5th, 9th–12th.	1st, 24th, 25th, 27th. Fog on 29th.
June.			
Temperature—			
Mean for month	74.5	70.4	71.2
Warmest day	16th 104	6th, 11th 102	28th 103
Coldest day	2d 46	16th 48	12th 44
Range	54	54	59
Greatest daily variation	16th 44	5th 43	13th, 27th 38
Least daily variation	1st, 24th 15	21st 16	4th 21
Mean daily range	30.1	30	30.5
Mean lowest	59.8	58	55.2
Mean highest	89.3	82.8	87.1
Rain on	1st, 18th, 24th.	15th, 21st.	
July.			
Temperature—			
Mean for month	77.7	78.7	78.6
Warmest day	18th, 19th 105	7th, 8th 104	6th, 27th, 31st 101
Coldest day	6th 52	2d 54	2d, 13th 52
Range	53	50	49
Greatest daily variation	8th 41	7th 44	19th, 20th 41
Least daily variation	29th 18	22d 22	11th 12
Mean daily range	33.5	30.5	32
Mean lowest	60.8	62.6	62.7
Mean highest	94.5	94.9	94.4
August.			
Temperature—			
Mean for month	72.2	72.2	75.1
Warmest day	1st, 30th 92	1st, 3d 99	2d 104
Coldest day	27th, 28th 49	21st 51	22d 49
Range	43	48	55
Greatest daily variation	1st 38	1st 42	11th 39
Least daily variation	17th 17	6th 20	17th 8
Mean daily range	29.2	29.6	29
Mean lowest	56	56.4	59.4
Mean highest	88.3	88	90.8
Rain on	3d, 4th, 6th.		
September.			
Temperature—			
Mean for month	72.7	64.5	66.7
Warmest day	24th 99	1st 94	14th, 15th, 16th, 17th 92
Coldest day	6th, 7th 47	27th, 30th 44	24th 42
Range	52	50	50
Greatest daily variation	23d 44	1st, 29th, 30th 36	8th 37
Least daily variation	28th 25	8th 8	23d 10
Mean daily range	35.2	26.3	27
Mean lowest	55	52	53.4
Mean highest	90.3	79	80
Rain on		11th, 12th.	22d, 23d, 25th.

TEMPERATURE RECORDS AT RANCHO CHICO—*Continued.*

	1899.	1900.	1901.
October.			
Temperature—			
Mean for month	58.8°	58.3°	65.2°
Warmest day	8th 96	8th 82	12th 89
Coldest day	15th, 24th 37	30th 35	29th 41
Range	59	47	48
Greatest daily variation	6th 41	8th 36	11th, 12th 36
Least daily variation	20th 5	4th 7	26th 12
Mean daily range	23.9	23	25.4
Mean lowest	46.8	46.8	53.2
Mean highest	70.8	69.7	77.1
Frost on	24th, 27th.	25th.	
Rain on	10th, 12th, 13th, 19th–22d, 29th, 30th.	2d, 3d, 4th, 11th, 18th, 19th, 27th, 30th, 31st.	17th, 23d, 25th–28th.
November.			
Temperature—			
Mean for month	53.9	52.9	54.4
Warmest day	13th, 14th 69	12th 74	3d 74
Coldest day	22d 36	28th, 29th 35	12th 36
Range	33	39	38
Greatest daily variation	2d 31	11th 31	4th 31
Least daily variation	11th 9	24th 5	19th, 23d 5
Mean daily range	18.5	19.3	19
Mean lowest	44.6	42.5	44.9
Mean highest	63.1	63.3	63.8
Frost on	23d.	28th.	11th, 12th.
Rain on	3d, 8th, 9th, 11th, 12th, 15th, 16th, 18th, 21st, 23d, 25th–29th.	7th, 15th, 16th, 17th, 19th, 20th, 21st, 24th, 25th, 30th.	9th, 15th, 16th, 19th, 20th, 23d, 28th.
Fog on		1st, 23d, 27th, 29th.	
December.			
Temperature—			
Mean for month	48.1	45.7	46.8
Warmest day	2d, 3d 64	21st 66	2d 68
Coldest day	20th 28	31st 23	16th 26
Range	36	43	42
Greatest daily variation	1st 24	27th, 28th 25	20th, 31st 30
Least daily variation	11th 6	10th 3	3d 1
Mean daily range	15	12.7	19.5
Mean lowest	44	39.1	37
Mean highest	52.2	52.2	56.5
Frost on	1st, 6th, 17th, 18th.	1st, 23d, 27th.	7th, 22d, 26th, 28th.
Rain on	4th, 7th–11th, 14th–16th, 29th–31st.	12th, 14th, 16th–20th.	2d, 3d, 5th, 9th.
Fog on	3d, 4th, 20th–29th.	2d–13th, 25th, 26th, 29th.	
Ice on	13th, 19th, 20th.	28th, 30th, 31st.	11th–21st, 29th.

STUDIES OF TREE GROWTH.

The fitness of this district to rapid growth of trees is illustrated by almost every measurement taken since the establishment of the station. Cultivation has been given to all the trees when small. The larger conifers now cover the ground so completely that cultivation is no longer necessary or practicable.

THE CONIFERS.

The most striking feature of the substation consists of large pines, cypresses, sequoias, and other conifers planted in blocks. The following table shows the comparative growth of a few species:

TABLE I. Representative Conifers.

Name.	No. of Trees Measured.	Av. Size, Oct., 1897.		Size, Oct., 1901.	
		Height.	Girth.	Height.	Girth.
Araucaria Bidwelli	1	12 ft.	6 in.	20 ft.	8 in.
Chamæcyparis Lawsoniana	5	18 "	22 "	21 "	30 "
Cupressus sempervirens	5	26 "	18 "	42 "	36 "
Pinus austriaca	5	18 "	16 "	22 "	21 "
Pinus insignis	5	25 "	28 "	32 "	42 "
Pinus resinosa	5	22 "	17 "	38 "	36 "
Pinus sylvestris	5	16 "	14 "	21 "	24 "
Pseudotsuga taxifolia	5	11 "	8 "	16 "	15 "
Sequoia gigantea	5	27 "	36 "	42 "	48 "
Sequoia sempervirens	5	22 "	16 "	43 "	46 "

These trees are in age fourteen or fifteen years from seed, but no record was kept at the station by those in charge before the University assumed control. There is but one *Araucaria*, and it stands too close to large oaks to have a fair chance. The numbers of the other species range from 10 (*Pseudotsuga*) to 400 and 500 (*Pinus sylvestris* and *Cupressus sempervirens*). The trees chosen stand on the outside of the blocks which are now being thinned.

The only difficulty in regard to the continued development of these blocks of conifers and the maturing of as large a timber-crop as this soil can possibly carry, lies in the nature of some of the root systems in transplanted trees. When a block of 225 trees of *Pinus resinosa* was partially thinned in the spring of 1902, a violent gale from the north blew down several of the standing trees, and showed conclusively that the roots of conifers planted in sacks, as these were in 1889, are more or less prevented from properly descending. There is no reason why much smaller conifers should not be used, or seeds sown under temporary shelter plants. In all cases where deep-rooted, healthy trees are desired, pines and other conifers can be transplanted from boxes when only a foot high, in small "puddled" balls of earth, without the use of sacks. Certainly the sacks should always be removed, not merely slashed across.

Self-sown seedlings already show in the groves, and the reproductive powers of any natural forest in this district, if properly protected, are evidently great. Allusion has been made to the rise of large oak groves, but no less interesting is the extent to which young *Pinus sabiniana* thickets abound on Rancho Chico. This forestry station shows on every hand satisfactory natural increase of many species, coniferous and deciduous.

Further Notes on Conifers.—There were two cedars, *Cedrus deodara* and *Cedrus Libani*, planted in 1895 at the eastern end of the substation. The former has far outgrown the latter, and is 23 feet high, with branches touching the ground; the latter is but 13½ feet high.

The Italian cypresses (*C. sempervirens*) are in some cases nearly 50 feet high, and are superb trees. Many are heavily branched, and the lower branches in these blocks begin to fall, but the columnar specimens still receive light on all sides.

The best block of *Pinus austriaca* averages over 25 feet high, with girths that often equal or exceed 20 inches, but the specimens tabulated were from a block of somewhat smaller size.

The growth of conifers in the mixed forest planted in January, 1895, affords the best illustration the substation can give of the ease and

rapidity of tree-growth here. The conifers are rapidly taking possession of the entire ground, and the larger maples, walnuts, catalpas, paulownias, and mulberries scattered through this two-acre plantation have been removed, leaving, however, many deciduous trees. All the conifers here were planted out when small by Mr. Boland, then foreman, and have deep root-systems.

The most remarkable growths made in the mixed forest were of *Pinus sabiniana*, many of which now stand more than 18 feet high. Three measured girths of 20, 22, and 23 inches. From seed these are but eight years old. It is a pity that the timber from this tree is not more valuable, but its usefulness in the foothills has hardly received sufficient attention, for it grows under very adverse conditions. The following brief table shows comparative growths of some of the mixed-forest conifers:

TABLE II. Measurements of Conifers in Mixed Forest.

Name.	No. Measured.	Age.	Height.	Girth.
Pinus sabiniana	5	8 to 9	18 ft.	21 in.
Pinus ponderosa	5	8 " 9	12 "	10 "
Pinus austriaca	5	8 " 9	11 "	9 "
Pinus lambertiana	5	8 " 9	10 "	8 "
Thuya gigantea	4	8 " 9	9 "	7 "
Larix europea	2	9	4 "	3 "

Conifers of Especial Value.—The experience of the substation leads us to recommend several species of conifers for more general planting in the Sacramento Valley and on the foothills. Among our native trees, *Pinus ponderosa*, the great yellow pine of the Sierra takes a prominent place. The redwood (*Sequoia sempervirens*) does much better than was expected, but on drier situations will not thrive so well. The growth and health of the Big Tree (*Sequoia gigantea*) shows that it may be extensively planted for ornament and shelter. The Monterey pine, though growing quite well, is best adapted to the coast; but the so-called Oregon pine (*Pseudotsuga*) is entirely at home here. The best exotic conifers tested are the Deodar cedar and *Pinus austriaca*. The latter is not as rapid in growth as some other species, but it makes a fine tree. There should be more attention paid by land-owners to the establishment of small groves of our native conifers, especially as windbreaks.

DECIDUOUS TREES.

The largest *European White Birch* among several of the same age, girths 30 inches and is 45 feet high. Its age is about fifteen years. A group of about seventy-five younger specimens of this birch (*Betula alba*), planted in 1895, small trees received by mail, are now (1902) from 35 to 40 feet high, and four girthed, respectively, 12, 14, 15, and 16 inches. Birches generally do well in this region, and any one who wishes may have a grove of this beautiful white-stem tree, the fastest-growing species of birch yet tested here.

Previous reports have described the two *Catalpa* (*C. speciosa*) groves. Small trees from self-sown seeds are frequently to be found here. The late General Bidwell planted many catalpas and distributed trees widely at various times from his nurseries. The average height of the catalpas at the substation in 1897 was 30 feet, with trunks 26 inches in

girth, breast-high. In 1902, three girthed 36, 40, and 46 inches. Young catalpas planted in 1895, when 3 feet high, are now (1902) 18 feet high and girth 12 inches. The catalpa seems to produce on a given area in a given time about twice the amount of wood as does the well-known Western box-elder (*Negundo Californica*), which is often planted for its rapid growth. Neither species, however, begins to yield as much wood as the paulownia.

The *Paulownia imperialis* of Japan is very little known, but it grows with such rapidity here that its more frequent growing can be recommended. Some remarkable measurements of this tree have been given in previous reports. This year (1902) one was measured which in two years had grown from an old stump to a height of 25 feet with a girth of 15 inches and was well-branched about 15 feet from the ground. Numbers of the older paulownia planted in 1889 are over 40 inches in girth; three, measured "as they came," were 45, 48, and 49 inches. One of the largest, near the grove of sequoias, girths 5½ feet. The commercial value of paulownia wood in California has not yet been determined, but many small articles of Japanese manufacture, such as toys, boxes, and furniture, are made of this light-brownish timber.

Several species of *Celtis* (nettle-tree) have grown very fast here. The best is *Celtis australis*, which, planted in 1896, now girth 12 and 14 inches and are 16 to 18 feet high. *C. occidentalis*, somewhat older, has also made very fine growth. *C. orientalis* is much behind the others. These are all trees of easy cultivation.

One of the disappointments here is the growth of *Zelkova keaki*, which ranks as the best hardwood of Japan. A lot of trees were obtained in 1895 and several thousand trees grown. These were widely distributed, and a block was planted here. The trees have never straightened up or made much growth. The increase of wood is only about one quarter that of American ash and half that of English oak. The tree does no better anywhere else, so far as tested in California.

The *Ashes* have deservedly attracted attention here, and no other hardwood better justifies planting for timber in this region, if the best species be used. *Fraxinus dimorpha* is small and slow of growth, but a beautiful ornamental. It comes from Algeria. Trees planted in 1896 are now (1902) 10 and 12 feet high, girthing 7 and 8 inches. *Fraxinus kabyla*, also from Algeria, is a much more striking species. Four measured (eight years from seed) girthed 16, 18, 19, and 20 inches, and they are 18 to 20 feet high, with fine trunks. *Fraxinus oregona*, of the same age, are only two thirds as large. *Fraxinus viridis* is also much poorer than *F. kabyla*. *Fraxinus alba*, however, the well-known American white ash, ranks in point of growth somewhat nearly with *F. kabyla*. Trees grown from seed in 1892 are now, ten years later, about as large as *F. kabyla* trees of eight years of age, and a few are even larger. The difference so far is perhaps ten per cent in favor of the foreigners. The older white ashes, in some cases, fourteen years of age, are very fine trees. One is 40 feet high and 3 feet in girth, and all are nearly as large as this. The best single ash upon the substation, considering age, is a white ash eleven years old, planted on the main avenue. It is 30 feet high, 10 feet to the lowest branch, and girths 28 inches. The growth of ash timber on such land as this should attract attention, as evidently in twenty or twenty-five years some cutting could be done. The growth of the white and the Kabyla ashes here has been about equal to that of

the strong-growing Japanese mulberry known as "Lhoo," and much surpasses that of the white or red mulberries.

Elms are often planted in this region. Two Huntingdon elms at the west gate, planted from the nursery in 1892, now girth 31 and 35 inches,

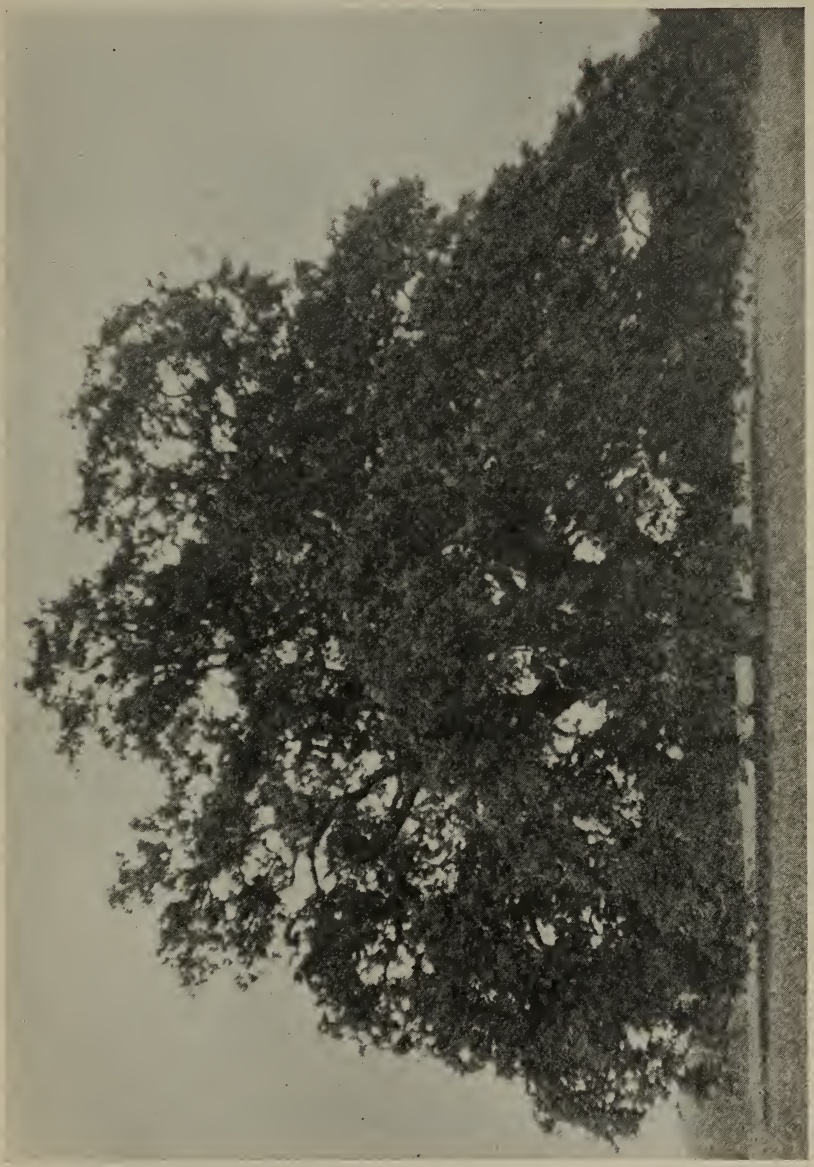


PLATE 16. THE HOOKER OAK, ON RANCHO CHICO, ONE MILE FROM CHICO FORESTRY SUBSTATION.

and have a very large spread of branches. They were in full bloom March 29, 1902.

English Oaks are well represented here, as well as many other species of *Quercus*. All have been planted since 1894, and many now bear acorns. Those left untrimmed are "bushy," branch near the ground,

and are far behind those that were pruned. The latter, now from seven to nine years old from the acorn, stand from 14 to 15 feet high, with trunks that girth from 8 to 15 inches. One tree, which was several years old when sent to the station, and is therefore about twelve years from the acorn, stands 22 feet high, with a trunk circumference of 21 inches. This region is one of the best oak districts in the State, and English oaks (*Q. robur*), or cork oaks (*Q. suber*), or any other desirable American or European species, can be grown here.

Quercus lobata has an excellent representative in the celebrated Hooker oak, which stands in the center of a large open glade, about a mile from the substation. This very shapely and beautiful tree, shown in the accompanying illustration (taken by Dr. Loughridge in 1900), was greatly admired by Sir Joseph Hooker when in California. The following are the dimensions as measured in July, 1894, by Mr. Boland, the foreman of the station:

Circumference of trunk	20 feet.
Circumference of largest branch	15⅛ "
Spread of limbs from trunk, on south	73 "
Spread of limbs from trunk, on north	63 "
Spread of limbs from east to west	112 "
Approximate height	100 "

The largest willow trees, *S. salmoni*, or *S. alba salmoni*, grown from cuttings planted in 1895, are over 60 feet high, and girth more than 30 inches. One of these trees is 68 feet in height, and its trunk is 38 inches around, measuring breast-high. Cuttings of this willow have now been widely distributed; it grows considerably faster than the common *Salix alba* form.

THE EUCALYPTS AND ACACIAS.

Previous reports have described the work done with many sorts of eucalyptus here. Their rapidity of growth is astonishing, and it would seem that profitable plantations of certain species could be planted in the Sacramento Valley.

The station recommends *E. rostrata* and *E. viminalis* as highly desirable species, whose timber is much more useful than that of *E. globulus*. Few large trees of *E. rostrata* exist here, the earlier plantings having been mainly of *E. viminalis*, but a few are scattered in the earlier plantation (established in 1889), and there is no appreciable difference in the growth of the two species. Both are desirable; the wood of *E. rostrata* is considered the more useful.

The following measurements of the older trees, now thirteen or fourteen years from seed, will show how the red gums have increased in this kindly soil and climate. In the old grove, five trees out of twenty-one of *E. viminalis* were measured, and girthed, respectively, 46, 48, 51, 57, and 61 inches. One girthed almost exactly 6 feet. These trees are 20, 30, and 40 feet to a branch. Trees of *E. rostrata*, of the same age, girthed 50, 52, 54, and 64 inches, and one was a little more than 6 feet around.

A superb grove of mixed species, *rostrata*, *viminalis*, *amygdalina*, and others, averages trees of 50 to 60 inches in girth and something over 100 feet high. The largest tree here is 6 feet 6 inches in girth. Many of these stand 8 x 8 feet apart, but the grove is long and narrow, receiving light on all sides.

The hardy species of eucalyptus of the newer sorts are *E. alpina*, *E. acerbula*, *E. leucoxylon*, and the superb *E. Foeld-Bay*, seed of which was received from Vilmorin in 1895. This last named is by far the best of all the new eucalypts. Planted out in 1896, when quite small, it girths 31 inches in 1902, and bids fair to outgrow both *E. rostrata* and *E. viminalis*.

Acacias.—The well-known *A. decurrens*, which suffered much from frost here while small, has made large trees at last, several being now 53 feet high, with trunks that girth nearly 5 feet. *A. melanoxylon* has never suffered seriously from frost.

CENTRAL EXPERIMENT STATION.

Berkeley, Alameda County.

TREE-PLANTING ON A BERKELEY HILLTOP.

By C. H. SHINN.

A significant experiment in tree-planting has been carried on for a number of years on a high hill-top in the northeastern part of the University tract at Berkeley. This tract comprises 249 acres (outside of the Hillegass tract) and rises, at first gradually, then more abruptly, from its western frontage on Oxford street to an elevation of 950 feet near the extreme northeastern corner. Its general appearance is familiar to the public, as a contour map has been printed on many occasions. It is sufficient to say here that the mountainous portion east of the building site contains about 125 acres, used as pasture land.

The soil is for the most part adobe; the native vegetation, confined to the cañons, consists of coast live-oaks, laurels, willows, and lesser shrubs. One stray madroño stands on the creek near the agricultural building.

Eucalypts.—Considerable planting of eucalypts (chiefly *E. globulus*), pines (chiefly Monterey), and other conifers was done soon after the University was established here, but nearly all on a level below 400 feet, where the soil was deep and could be easily plowed. The growth of these trees has been rapid, and, in many respects, surprising. One large block of almost two thirds of an acre, situated west of the cinder track at the union of the two creeks, has long been recognized as one of the most instructive eucalyptus groves of its size in this part of California (see Plate 17). There are about two hundred and fifty trees here, the largest of which now girths 7½ feet, breast-high.

The trees on the outer edge of this grove range from 40 to 90 inches in girth, stand 8 to 10 feet apart, and often rise 40 feet without a branch; in the middle of the grove the trees are from 18 to 30 inches in circumference, but with even taller shafts. It is estimated that this grove, if cut for fuel, would yield about 400 cords of firewood, or at the rate of about 600 cords per acre.

One eucalyptus tree cut on the Hillegass tract in 1901 was measured by the writer. Its age was twenty-four years and its diameters were 26 inches and 31 inches after the bark had been stripped off. Yields of 800 cords to the acre have been reported from trees of twenty years of age. Ten-year-old red gums grown by Mr. J. C. McCubbin, of Reedley, yielded at the rate of 235 cords of wood per acre, and it was by him reported to have from 85 to 90 per cent of the fuel value of mountain live-oak. (Whether this was *E. rostrata* or *E. viminalis* was not reported.)

On the hills, where the soil is scantier, the rainfall of less amount, and trees more exposed to winds, the growth is necessarily very much less than it is on the flat. Such hill land as this, however, has only a pasture value, as it is not suitable for early vegetables, and is too steep for grain.

In 1887 the Director of the Experiment Station had several hundred trees planted near the top of a knoll at an elevation of 800 feet. The slope here is west and northwest and is fully exposed to the winds. It

PLATE 17. EUCALYPTUS GROVE (*E. globulus*), NEAR ECONOMIC GARDEN.

was therefore, as a site, hardly equal to the average. The trees planted were English oaks, cork oaks, Monterey pines, and Monterey cypresses.

In 1888 some *Acacia decurrens* were added to the plantation, and a few miscellaneous trees, most of which died. In 1892 a row of *Eucalyptus corynocalyx*, or sugar gum, and in 1892 some *Eucalyptus globulus* were planted here. The latter were set at a considerably higher point, or at nearly 900 feet elevation. All these trees have been subject to pasture conditions, have received no care nor cultivation, and hence can not be said to give an exaggerated idea of the growth that might be expected on such Coast Range slopes as these.

PLATE 18. E. GLOBULUS IN ADOBE SOIL OF HILLTOP.

The growth of the common blue gum, *Eucalyptus globulus*, now ten years planted, is greater than that of any other trees tested. Four trees standing near the crest of the hill, at an elevation of nearly 900 feet above the sea (or 785 feet above the Oxford street entrance to the University grounds), now show an average girth of 28 inches. The largest girths 33 inches. They are from 40 to 45 feet high and were planted 8

feet apart. They are now growing very fast. (Plate 18 shows three of these trees.)

The sugar gums (*Eucalyptus corynocalyx*), which are two years older than the blue gums, are planted on the eastern side of the main grove, which consists largely of oaks. These trees, now twelve years old, range in girth from 20 to 30 inches, and are 20 to 25 feet high. The trunks are short, not exceeding 5 feet, and many branch near the ground. The tops spread widely; cattle have eaten the leaves and smaller limbs within reach.

PLATE 19. ACACIA DECURRENS, ON HILLTOP.

Acacias.—The plantings of acacia originally made included *melanoxylon* and *decurrens*. The former have died; the latter are so large and healthy as amply to justify large plantations on such soils.

One of two *Acacia decurrens* near the north line, close to the fence and isolated from the main grove, is shown in Plate 19. This tree stands

on a northern slope, on heavy adobe soil, with native vegetation of clover, wild oats, foxtail, etc. It girths 42 inches near the ground. The main stems girth 27 and 30 inches. The height of the tree is 30 feet. Cattle have destroyed all the lower branches. Trees of *Acacia decurrens* in the main grove, surrounded by eucalypti and oaks, girth from 38 to 40 inches (single stems).

The amount of firewood per acre furnished under these conditions by *Acacia decurrens* is greater than that from *E. corynocalyx*, but is less than that from *E. globulus*. In fuel value the acacia wood is estimated to rank higher than that of either eucalyptus. But the chief value of *Acacia decurrens*, its yield of tan bark, deserves especial consideration. Planted in a grove on such land as this, the yield of bark in, say, eight years, would be considerable. It should be fully twice as much per

PLATE 20. ENGLISH OAKS ON HILLTOP.

acre as from the lighter and more arid Santa Monica grove (see report for 1897–8, pp. 227–230). Wattle barks, as therein reported by an expert tanner after practical tests, are "as good value at $28 a ton as oak bark at $18 a ton."

Acacia pycnantha has not been tested on this hill-top. *A. mollissima*, as well as *A. decurrens* and some of the ornamental species, were planted in the southeastern portion of the tract, on a slope near Strawberry Creek, at an elevation of about 427 feet. Here the growth of the wattle acacias was very rapid, girths of from 4 to 5 feet being reached in fifteen years from planting. In this location the acacias showed considerable power of reproduction from sprouts when trees were cut and from self-sown seeds.

Oaks.—The oaks, planted in 1887 on the hilltop, elevation 800 feet, consisted of about one hundred and twenty English (*Quercus pedunculata*) and twenty cork oaks (*Q. suber*). At the present time, ninety-eight

English oaks and fifteen cork oaks remain. Many of these are branched, shrubby, and spreading, and have suffered from being browsed upon; but forty-nine of the English oaks are of good size, with trunks girthing over 15 inches, and twenty of these exceed 18 inches. The average

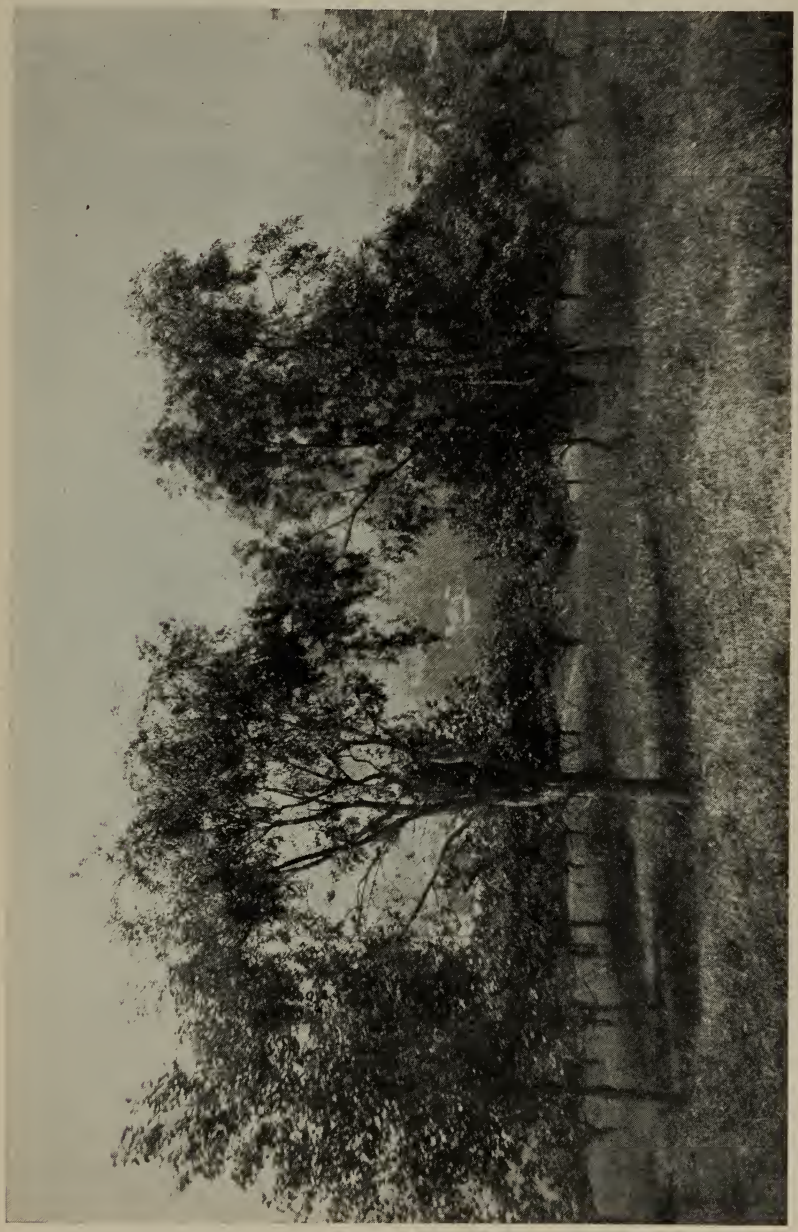


PLATE 21. GROVE OF OAKS, EUCALYPTS, ETC., ON HILLTOP.

height of the English oaks, however, is only 10 or 12 feet. Eight or nine trees are much taller than this, and are conquering the unfortunate tendency toward a shrubby growth. (See central oak in Plate 20.)

The best cork oaks are rather larger in girth of trunks than are the

English oaks; three are 16, 20, and 23 inches, respectively, above the ground. Of the fifteen trees, six will average fully 10 feet in height, while the others are more or less scrubby. Both cork and English oaks are very healthy, and seem as well established here as any native tree in the adjacent gulches. The oaks are on a dry western slope, where the pasturage was turning brown May 24th.

The only profit possible from oak plantations in such soil as this must come from trees constantly side-pruned and cultivated for several years. If a shrubby growth can be avoided, both the English and the cork oaks will thrive here. A plantation of twenty or more acres of cork oaks would give the matter a thorough practical test.

Other Trees.—Pines of several species planted here made good growth, reaching in some cases a girth of 15 inches, but were broken down by cattle. Monterey cypresses, though still alive, are now mere clumps with dozens of scattered stems. Cork-bark elms failed. Two California poplars (*Populus Fremonti*) are growing well, but have no economic value as compared with the eucalypts, acacias, and oaks.

Conclusions.—The poorest part of the grove is at the extreme west, exposed to the full sweep of the wind. Gophers and cattle, not drought or native vegetation, destroyed most of the trees which died. Fenced from cattle and given some cultivation the first few years, the growth would have been much greater than it is. In a larger plantation, too, the mutual shelter afforded by the young trees would be considerable.

But in spite of all drawbacks, *Acacia decurrens*, eucalypts, and oaks are well established here. Land as steep as this is rented at from fifty cents to a dollar an acre per annum, and is only used for pasturage. There are thousands of acres of such land in the Coast Range within fifty miles of San Francisco that will pay interest on a much higher valuation, if used for growing firewood, not to say a better quality of timber. As the general illustration (Plate 21) shows, the grove of oaks, eucalypts, and acacias, though small, covers the ground well, is healthy, and gives good evidence of the value of these hilltops for tree growth. On even steeper slopes and on the very crest of the Coast Range, numerous groves of blue gums exist which are now yielding profitable returns. Larger forests should therefore be planted, and other species of eucalyptus, also the wattle acacias, as well as oaks, should be given consideration.

NOTE ON THE COMPOSITION OF THE ADOBE SOIL OF THE HILLTOP.

By E. W. HILGARD.

The soil of the hilltop where the grove is situated is a very hard and black adobe clay, cracking open when dry, breaking up in lumps, and very difficult to remove, even with a pick. Samples were taken to a depth of three feet in a representative part of the grove, and those of the first and third feet subjected to a mechanical and chemical analysis by Prof. Loughridge and Mr. Triebel in the station laboratory, with the results given below.

There was in each sample from 12 to 15 per cent of coarse grits and rock fragments, which was sifted out and the analysis made of the fine earth having a diameter of one half millimeter and less.

Nos. 2430, 2432. Mechanical Composition of Hilltop Adobe: Berkeley.

Hydraulic Value. Velocity per Second.	Diameter of Grains.	Physical Characteristics.	First Foot. No. 2430.	Third Foot. No. 2432.
			Per cent.	*Per cent.*
Ab've 64 mm.	Above ½ mm.	Grits	12–15	12–15
64 "	.50 –.30 "	Very coarse sand	4.21	.18
64–32 "	.30 –.16 "	Coarse sand	7.21	.28
32–16 "	.16 –.12 "	Medium sand	3.89	2.11
16– 8 "	.12 –.072 "	Fine sand	5.48	3.18
8– 4 "	.072 –.047 "	Coarsest silt	5.16	2.83
4– 2 "	.047 –.036 "	Coarse silt	4.13	2.75
2– 1 "	.036 –.025 "	Medium silt	4.30	2.82
1– 0.5 "	.025 –.016 "	Fine silt	1.80	4.10
0. 5– 0.25 "	.016 –.0023 "	Finest silt	42.62	51.02
0.25– ? "	.0023– ? "	Colloid clay	20.18	30.45
			98.98	99.72

The soil mass is of rather extreme physical composition, in the great predominance of very fine materials, amounting in the subsoil to over 80 per cent; and such land must always be difficult to handle in cultivation, and be uncertain on account of its dependence upon favorable rainfall. Unless very deeply cultivated it will crack open in summer, tearing the roots and drying the soil into a mass of rocky hardness. As it is not intrinsically very rich, it would be desirable to utilize it for suitable timber growth, provided sufficient root-penetration can be secured. The lack of this is probably one cause of the low growth of the English oak.

Chemical Analysis of Adobe Soil of Berkeley Hills, No. 2430.

		Per cent.
Insoluble matter	72.19	78.70
Soluble silica	6.51	
Potash (K_2O)		.33
Soda (Na_2O)		.29
Lime (CaO)		.76
Magnesia (MgO)		.76
Br. ox. of manganese (Mn_3O_4)		.08
Peroxid of iron (Fe_2O_3)		6.02
Alumina (Al_2O_3)		4.58
Phosphoric acid (P_2O_5)		.07
Sulfuric acid (SO_3)		.02
Water and organic matter		8.93
Total		99.72
Humus		1.85
Nitrogen, per cent in humus		8.70
Nitrogen, per cent in soil		.16
Hygroscopic moisture (absorbed at 15° C)		9.09

In its chemical composition this soil, as might be expected, does not differ widely from that of the lower slopes and the yellow ridge soil of the University grounds (No. 4, in Report of 1884). It is poor in potash for a California soil; and for so heavy a material the lime content, although relatively high from a general point of view, is too low to insure ready tillage. The content of phosphoric acid is an average one, its humus content is good for the arid region, and the nitrogen percentage of the humus sufficiently high. The fact that in years of abundant rainfall this land bears a very heavy growth of grasses and certain classes of weeds, shows that if improved in texture it might be highly productive for a time.